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CONTENTS.

Some Aspects of the Half-Watt per C. P. Tungsten Lamp

The two papers by Dr. I. Langmuir published elsewhere in this issue on the new nitrogen-filled tungsten lamp mark a new milestone in the development of the electric incandescent lamp.

Oct. 21, 1879, is considered as the birthday of the electric incandescent lamp, since on that day Edison carbonized a piece of cotton sewing thread bent into a loop of horseshoe form and had it sealed in a glass globe from which the air was afterwards exhausted. Edison's genius solved the carbon-lamp problem so completely that for somewhat like twenty-five years the carbon lamp reigned supreme in incandescent lighting, until a little over ten years ago the first metallic-filament lamp appeared.

With the single exception of the Nernst lamp, which was an ingenious invention and a big thing in its day, but is now only of theoretical and historical interest, the whole development of the last ten years has been along the line of the metallic filament. The metallized carbon filament may first be mentioned which reduced the specific consumption of 3 watts per cp of the ordinary carbon lamp to 2.5 watts per cp. Then came the osmium lam. the tantalum lamp (2 watts per cp), the tungsten lamp (1.25 watts per cp), the ductile tungsten lamp (1 watt per cp), and now we have the nitrogen-filled tungsten lamp consuming but 0.5 watt per cp.

The general public is liable to look at this development as a triumph of electrical engineering. In reality it is step by step one continuous triumph of physico-chemical research. Just as in gas lighting and in electric-arc lighting the most notable advances—the incandescent gas mantle and the impregnated carbons of the flaming arc—have been the result of the work of the chemist. thus the evolution of the metallic-filament just sketched shows one pre-eminent leitmotiv of physico-chemical nature.

If we consider the light given out by an incandescent lamp as "pure temperature radiation," the radiation laws indicate that any increase in the operating temperature of the radiating filament must vastly increase the efficiency for two reasons: Firstly, because according to the Stephan-Boltzmann law the total radiation increases as the fourth power of the absolute temperature, and, secondly, because according to Wien's law of the displacement of the maximum in the energy spectrum, more of the radiation falls within the range of visible spectrum. Hence increase in temperature filament has been the leitmotiv.

Naturally the first limit to such increase is set by the melting point of the filament, and this consideration is clearly indicated in the historical development by the successive experimentation with metals of higher and higher melting points. Osmium was followed by tantalum and tantalum by tungsten. Soon, however, it was recognized that before the fusion point could be reached, evaporation of

the metal, resulting in blackening of the globe, would set a limit to the operating temperature of the filament. And it is this limitation which has now been overcome by the nitrogen-filled tungsten lamp. Evaporation is held back or controlled within inoffensive channels and this makes it possible to increase again the operating temperature of the tungsten filament with such a gain of luminous efficiency that in spite of the loss by conduction of heat through the nitrogen atmosphere the specific consumption in watts per candle-power is cut in half.

The whole development has been international. In Europe Baron Auer von Welsbach and, in connection with the tantalum lamp, the chemists of Siemens & Halske have been pre-eminent among many active and able workers. But credit for the metallized-carbon lamp, for ductile tungsten, and for the nitrogen-filled tungsten lamp is due solely to the United States. Glorious work has been done by the Research Department of the General Electric Company under the genial leadership of Dr. W .R. Whitney. With his staff of able co-workers, men like Dr. W. D. Coolidge, he has directed extended researches on a strictly scientific basis, leading to the invention of ductile tungsten by Dr. C. G. Fink and the invention of the nitrogen-filled lamp by Dr. I. Langmuir.

Thus there should be glory enough for all. But that the new nitrogen-filled tungsten lamp is something great, is indicated in a rather amusing manner by the way how it has been announced in Europe. At the last convention of the German Association of Electrical Engineers Herr Salomon said: "Recently the Allgemeine Elektricitäts Geselischaft has succeeded by the application of new means in making tungsten-filament lamps which have all other advantages of these lamps but consume only 0.5 watt per candle" (*Elektrotechn. Zeitschr.*, Aug. 14, 1913, page 955). Not one word about the inventor. Perhaps more diplomatic was the announcement in Great Britain "that the credit of evolving this lamp belonged to the British Thomson-Houston and associated companies, having been developed first at the laboratory of the Schenectady works by Mr. W. C. Whitney" (London *Electrical Engineering*, Aug. 28, page 487). Well, the compliment paid indirectly to physico-chemical research in the United States is genuine and sincere.

Cyanide from Beet-Sugar Waste

The removal of a 12½% *ad valorem* protective tariff on imports of potassium cyanide directs attention to the status of cyanide manufacture in this country and abroad. The largest domestic manufacturer, combatting the proposal to place cyanide on the free list, stated that 5000 tons of sodium cyanide were manufactured in the United States in 1912, and urged the retention of the duty.

Chemical manufacturing in this country undoubtedly suffers by comparison with the much older and more highly developed industry in Europe, particularly in Germany. The German manufacture of alkali cyanide as a by-product from beet-sugar molasses is a case in point. It appears that beet-sugar molasses contains about 5% potash and 2% nitrogen. If the sucrose is precipitated and removed, the residue becomes a concentrate of potash and nitrogenous materials; and it is this residue, molasses *schlempe*,

which the Germans convert partly into alkali cyanide. The residue is distilled at about 400° C., yielding gaseous compounds of nitrogen which, on being heated to about 1000° C., synthesize ammonium cyanide. This is decomposed by sulphuric acid, forming ammonium sulphate and hydrocyanic acid, the latter being then absorbed in sodium hydroxide. The quantity of sodium cyanide thus produced annually in Germany approximates 5000 tons, which finds a market in South Africa.

We too have a large beet-sugar industry and might convert molasses partly into cyanides; but under our conditions the saccharine by-product finds use largely as a component of food for cattle and other stock. The case is only one of many which illustrate the difference in methods between a highly organized old industrial community on the one hand, and a new country rich in natural resources on the other. It would be a big mistake to conclude that what is industrially successful in the one would be *eo ipso* economically promising in the other.

Leaching Copper Ores and Tailings

The great amount of experimental work going on in the West in the leaching of low-grade copper ores and tailings, calls attention to a marked change in the attitude of metallurgists toward such processes. Whereas, not many years ago, the hydrometallurgy of copper was regarded with suspicion, and the men who advocated it met with scornful criticism, today the tables are turned and some of the best talent in the country is engaged in this work, with reasonable prospects of success. The change is a consequence of technical progress, stimulated by the necessity of making the most of our resources; but in a broader light it is only one phase of the tendency toward a more general consideration of hydrometallurgical methods. With the realization of the limitations of current processes, attention is being directed toward chemical treatment in the wet way.

It is recognized that in the leaching of copper ores, no method of general application is likely to be evolved; and that each case presents a separate problem, varying with the material to be treated, the locality and the prevailing economic conditions. Leaching, of itself, is not a difficult feature; nor is the preparation of ore to make it amenable to leaching an insurmountable obstacle. Common salt and sulphuric acid are plentiful and cheap commodities. The latter can be produced as a by-product where ores are roasted on a large scale, so that with an increase in demand a plentiful supply can be assured.

Precipitation of the copper from solution appears to be the stumbling block and the point on which the different processes now under way are most widely divergent. Electricity, hydrogen sulphide, and iron are the agents thus far proposed and used. All three are in use in Montana: electricity at the Butte & Duluth and the Bullwhacker, hydrogen sulphide at Anaconda, and iron at the plants precipitating mine water. Electrolysis and precipitation on iron have been widely experimented with in Arizona. In the electrolytic work at one plant, the sulphur dioxide gas obtained from roasting the ore is bubbled through the electrolytic vats to prevent polarization.

Scrap iron is almost always suggested as a precipitant, but usually without thought of the difficulty of securing an

adequate supply in the isolated districts where much of the leaching is done. Further, the efficiency of precipitation and the quality of the precipitate are affected by the nature of the scrap, as Mr. Febles showed in his paper at the Butte meeting of the Institute. On the other hand, while the use of a suitable grade of pig iron is not commonly considered, it is not impracticable in certain localities. In the Southwest, for example, both domestic and imported pig iron can be bought for $11 or $12 per ton, and probably laid down at the plant for less than one per cent per pound. Compared with poor quality scrap at Butte for $7 or $8, and old rails at $11 per ton, the use of pig iron might not be out of the question in certain localities.

Another phase of iron precipitation, however, is more interesting. Iron sponge, or metallized iron oxide, can be produced by the "step-reduction" of iron ore, as in the Jones process which was tried in Michigan. This reduction process has been applied to pyritic calcine, obtaining thereby spongy iron or iron dust, according to the fineness of the material. Experiments have shown this to be an excellent precipitant of copper. The advantageous feature of the method lies in the fact that sulphuric acid for leaching could be made from pyrite, and the resulting calcine reduced to iron sponge for precipitation of copper solutions. It might even be possible to roast chalcopyrite, leaching the copper with the acid formed from the roaster gases, dry and reduce the iron oxide residue and use it as a precipitant. While this method of operation has been tried only in a small way, it is known that the investigators are hopeful of its success under suitable conditions.

The American Iron and Steel Institute.

Although it is four and a half years since the American Iron and Steel Institute was chartered, it is hardly two years since the organization began to secure papers of importance. As The Iron and Steel Institute—with the necessary accent upon the particle—is quite cosmopolitan in character and indeed numbers in its membership many American steel manufacturers and engineers, one is naturally eager to seek means for differentiating the two organizations. The Institute, which has its headquarters in England, in plain terms, can be held to "fill the bill" for the iron and steel industry of the world unless, or until, another organization shows a *raison d'être*.

The American Institute is doing well, for so young an organization, in defining a place for itself, and the papers presented at the semi-annual meeting, Oct. 24-25, in Chicago, make a fair showing when viewed in the general sense, and serve in particular to indicate that the American Institute has work of a somewhat different nature from that which the cosmopolitan Institute has done so well for many years.

Upon all subjects it is hazardous to generalize, but if the statement be not proved accurate it is at least suggestive that while the papers of the older Institute seem to be prepared largely by the men who study steel, the papers of the American Institute are prepared by those who make and sell steel. They deal less with molecular structures and more with how to get out the tonnage and how to adapt steel to new and specific uses. As to one point of differentiation a generalization is accurate, that the cosmo-

politan Institute never deals even remotely with commercial practices, its constitution forbidding, while the American Institute does. Three years ago a paper was presented, and discussed by the most prominent steel manufacturers in the country, on "Contract Obligations in the Steel Trade" and a year and a half ago a paper upon the same subject was given. The object was that contracts for the sale of finished steel products should be binding, instead of being mere options given by seller to buyer. The aim is to correct a crying evil which exists in the American trade but which is not found abroad. Unfortunately, no improvement can be traced directly to the airing given the subject before the Institute.

At the recent Chicago meeting another important commercial subject was discussed, that of "extras," several speakers insisting that the recognized extras represent an added cost of manufacture and are thus neither a bonus nor a source of extra profit, while some of the speakers specifically gave the advice that if a manufacturer desired to name a particularly attractive price he should do so by reducing his base price and not by conceding one iota of the extra. In any branch of manufacture it is recognized that the first step towards removing a difficulty must be to find and define its cause. Commerce, it appears, does not necessarily accept this principle, for one cannot find in these papers a clear statement of why extras are cut. In the case of many extras, and nearly all those which arise from the piece being of a particular cross-section, the extra cost upon which the card extra is based is a cost due to time lost in roll changing or to reduced output of the mill while actually rolling the material. When mills are running at less than full capacity this element of cost is reduced, possibly to insignificant proportions, and it is a recognized fact that it is when the market is dull and mills are not fully employed that extras are cut. This is the explanation. We do not for an instant imagine it is without the ken of those who read the papers at Chicago, our object being merely to point out that it escaped specific mention, whereas had the subject been mechanical, metallurgical or chemical, instead of commercial, the cause of the evil would have been stated as the foundation of the paper. Hence it may be questioned whether as much light can be thrown upon the problems of selling as upon the problems of manufacturing, by the reading of papers.

However, we must remember there was a time when papers upon manufacturing processes were rare because those who had knowledge preferred almost invariably to keep it to themselves. Their view broadened eventually. The reading of papers upon commercial subjects is in its infancy and in time the subjects may be handled with adequate precision and frankness.

With enterprise and directness characteristic of its locus, the American Iron and Steel Institute invites the user as well as the producer of steel to contribute to its meetings, and so at Chicago there was a paper on the steel car wheel by a producer, followed immediately by a paper from the superintendent of motive power of the Pennsylvania Lines West, giving the viewpoint of the user. Obviously this is practical, and bound to promote real progress, for after all the end of all endeavor with respect to steel is to make it render more and more service to man.

Readers' Views and Comments

"Hydrometallurgy—Joys of Its Theory, Woes of Its Practice"

To the Editor of Metallurgical & Chemical Engineering:

Sir:—In your October issue I note Mr. Warren F. Bleecker's review of my article, published under the above caption, in the September number. In Mr. Bleecker's comments, page 539, he draws the inference that I made specific allusion to a difficulty in the Malm process of dry chlorination.

The stoppage in question was not incidental to the Malm process, nor was the impurity calcium sulphate. So far as I personally am concerned the correction is of no value, but I wish to relieve Mr. Malm from the implication.

Golden, Colo. REGIS CHAUVENET.

Slime Thickeners

To the Editor of Metallurgical & Chemical Engineering:

Sir:—I note in your issue of September, 1913, page 528, in the report of the very valuable paper of Mr. Hayden on Slime Concentration at Anaconda, that you quote the following:

"The Dorr tank has nearly the same settling capacity per square foot of settling area as the smaller unit," etc.

As compared with this information obtained from the Anaconda tests, we have advices from one of the largest gold-mining companies, which has installed a 44-ft. thickener to operate against 20-ft. settling tanks previously used, that they apparently get an increase of capacity per square foot of 5 to 10 per cent. We have also the statement of the superintendent of one of the largest copper companies in Nevada, who put in Dorr thickeners after operating small cones for a number of years, and who says:

"We are getting most excellent results from the thickener, using the overflow of two thickeners for wash-water on forty Wilfley tables and occasionally a surplus for use as wash-water on vanners. One thickener 17 ft. diameter by 9 ft. deep has a greater capacity than twelve 8-ft. cones, for the reason that there is only one unit to watch instead of twelve, without the constant result of feed to twelve cones becoming unbalanced. Also the 1⅛-in. spigot used on the thickener requires no attention compared with the dozen ⅜-in. spigots of the cones. We have never had a moment's trouble with the thickeners in any way since their installation."

It will be noted, of course, that the difference between the results obtained here and those at Anaconda is that the latter were compared with tests made on cones and not in regular mill operations. JOHN V. N. DORR.

Denver, Colo.

High-Resistance Pyrometers

To the Editor of Metallurgical and Chemical Engineering:

Sir:—It is seldom that we have occasion to take exception to anything published in your journal, but the article on "a new high-resistance thermo-electric pyrometer," published on page 596 of your October issue, contains obvious errors.

Setting aside the fact that our company has been building high-resistance galvanometers of the pivoted type for more than four years, with a resistance averaging from 75 to 100 ohms, depending upon the range of temperature to be covered, the statement concerning the effect of the length of leads upon the accuracy of the instrument is obviously wrong. The resistance of 1000 ft. of No. 12 wire is 1.5 ohms, and the resistance of 1000 ft. of No. 14 wire is 2.5 ohms, hence the former would cause an error of 15 deg. at 1000° F, and the latter an error of 25° in the reading of the instruments at the same temperature, these errors being doubled at 2000° and tripled at 3000° F. If the ordinary acceptation of the wording is taken and a distance of 1000 ft. between the instrument and thermocouple is meant, the errors illustrated above would be doubled, making a maximum error at 3000° F. of 90° for the No. 12 wire and 150° for the No. 14. For our "high-resistance" instruments we are contenting ourselves with the statement that a variation of from 50 to 100 ft. in distance makes no appreciable error in the reading.

The statement relative to the effect of a change in length of leads on the average low resistance instrument contains an even greater error. Assuming an instrument to have a total resistance of 5 ohms, including the length of the leads, the elimination of 50 ft. in distance of these leads would mean an elimination of 25 ohms, or 1/20th of the total resistance, causing an error in the reading of the instrument at 1000° of 50°, 100° at 2000° and 150° at 3000°. With an instrument having a total resistance of 100 ohms, a change of 100 ft. in length of leads would mean a variation in resistance of .5 ohm, causing an error at 1000° of 5°, 10° at 2000° and 15° at 3000°. In all these illustrations the nature of the error would be governed by the insertion or removal of the resistance in question, the insertion of resistance causing the instrument to read lower, the removal of resistance causing it to read high. For this reason the examples quoted above are not mathematically correct, as the exact percentage of error would depend on whether the leads were lengthened or shortened.

We also wish to state that we have in our laboratory a wall type pyrometer built by Siemens-Halske Co., having an internal resistance of 152 ohms and to our knowledge they have been building this type of instrument for a number of years.

D. C. DRAPER.

Thwing Instrument Company,
Philadelphia,.Pa.

* * *

To the Editor of Metallurgical and Chemical Engineering:

Sir:—The article on a new high-resistance pyrometer, published on page 596 of your October issue. claims a new achievement in pyrometer apparatus.

In short. the article refers to a pyrometer indicator having an internal resistance of 100 ohms, the instrument being of the switchboard or wall pattern, and it is stated that this is a new achievement. Actually, the reader is given no opportunity to judge of the reasonableness of this claim because other factors are not mentioned. A galvanometer or milli-voltmeter might have 100 ohms resistance for say, 50 milli-volts, which is about the range of instruments generally used with base metal couples and the same instrument would have about 40 ohms when used with the range of only 20 millivolts, which is the approximate electromotive force of platinum-rhodium couples when used for their highest possible readings. Still further information as to what portion of the internal resistance is in copper and what in wire having negligible temperature co-efficient, would be necessary in order that one might intelligently pass on what has been achieved in an instrument of this general character.

But while that is highly important, it is not at all the point we wish to cover here and we refer to it to call your attention to the fact that the achievement represented in the instrument described in the above mentioned article is not proven by the necessary data in regard to the instrument itself but reliance for proving the point of new achievement rests entirely upon a statement in regard to what has been achieved or not achieved by others. This statement we now quote:

"It is true that for some time high-resistance galvanometers or millivoltmeters, portable in form, but not of the switchboard or wall pattern, have been produced abroad."

This statement does gross injustice, not simply to ourselves, but to many other makers of high-grade scientific apparatus. Pyrometry has been of invaluable assistance in metallurgical and other industrial work involving high temperatures.

Factors that are necessary for a high order of accuracy in temperature measurement are not known to all who wish to acquire that order of accuracy and the article we refer to is well adapted to mislead many of your readers.

We shall refute the statement on which that article mainly relies, by some data on our own instruments after here making clear that the statement does injustice to apparatus of some other makers as well as ourselves.

Our 1908 catalog illustrates and describes a wall-pattern high-resistance instrument, not of the suspended-coil type, not requiring to be set level; as well as a portable instrument of the same general type. Those instruments were furnished with 100 ohms for 20 millivolts with platinum-rhodium couples and when used with our base-metal couples they were furnished with 280 ohms internal resistance. These instruments were in every way a success and have been sold extensively for over five years in the face of much opposition by those who were not at that time making instruments anywhere near approaching such resistance, and were pointing out at that time that high resistance was not really so very necessary.

In the last five years we have been making pyrometers with base-metal couples and the resistance as high as 400 ohms in the indicator with 87 per cent of that resistance in wire of negligible temperature coefficient on the series coil and all of these instruments have been made in both portable form and the wall pattern or switchboard type. Yet according to the article above mentioned, that has not heretofore been done.

CHAS. H. WILSON.

Wilson-Maeulen Co., New York City.

Gold in Sea Water

To the Editor of Metallurgical and Chemical Engineering:

Sir:—Professor Regis Chauvenet, in his very interesting article on Hydrometallurgy, on pages 486 to 491 of your September issue, has apparently taken someone else's word for some of his statements, without trying to substantiate them for himself. He says "for many years a paragraph had been floating around the world stating that sea water contains a definite proportion of gold. One metallurgist has taken the trouble to trace the statement to its source, with the result that the trail 'ran up a tree.' No authoritative statement of the contents of gold 'per ton of ocean' could be discovered. * * * Possibly there is some infinitesimal trace of gold there. Certainly there is not that much (1 grain per ton)."

If Professor Chauvenet will turn to page 111 of the second edition of F. W. Clarke's monograph, "The Data of Geochemistry," he will find the following: "The fact that sea water contains gold was first established by E. Sonstadt in 1872 [Chem. News, 25, 196, 231, 241, (1872); 74, 316 (1896); Am. Chemist, 3, 206, (1872)]. Its presence has since repeatedly been verified. In 1892 C. A. Munster [Jour. Soc. Chem. Ind., 11, 351, (1892) From Norck Tekn. Tidsskr.] examined water from the Kristiania Fjord, Norway, and found in it 5 to 6 milligrams of gold, with 19 to 20 of silver, per ton. In each analysis he used 100 liters of water. Liversidge [Proc. Roy. Soc. New So. Wales, 29, 335, 350 (1895)] found the gold in Australian waters to range from 0.5 to 1.0 grain per ton. At either rate, gold is present in the ocean in thousands of millions of tons. Liversidge [Jour. Chem. Soc., 71, 298 (1897)] also detected gold in kelp, rock salt, and a number of saline minerals, such as sylvine, kainite, carnallite and Chilean niter. In one sample of kelp he found 22 grains of gold per ton, and in a bittern, 5.08 grains. J. R. Don [Trans. Am. Inst. Min. Eng., 27, 615 (1897)] examined both ocean water and oceanic sediments. In the former he detected 0.071 grain of gold per metric ton, but the sediments were barren. In waters collected near the Bay of San Francisco, Wagoner [Trans. Am. Inst. Min. Eng., 31, 806 (1901)] found, also per metric ton, 11.1 milligrams of gold and 169.5 of silver. In deep sea dredgings Wagoner detected even larger quantities of both precious metals. [Trans. Am. Inst. Min. Eng., 38, 704 (1907)]. P. DeWilde [Arch. Sci. Phys. Nat., (IV), 19, 559 (1905)] and

A. Wiesler [Zeitschr. angew. Chem., p. 1795 (1906)] have published good summaries relative to the detection of gold in sea water, and also discussed the possibility of its economic recovery."

It appears then, that the trail that "ran up a tree" has run down again on the other side.

G. A. ROUSH.

Lehigh University,
　South Bethlehem, Pa.

Electric Zinc Smelting

To the Editor of the Metallurgical and Chemical Engineering:

SIR: In the August issue of METALLURGICAL AND CHEMICAL ENGINEERING a letter is published from Mr. F. L. Clerc commenting upon my article which appeared in the issue of November, 1912, entitled "Causes of the Practical Non-success of Electric Furnaces in Treating Zinc Ores."

Although my poor knowledge of English compels me to avail myself of translators who are liable to alter sometimes the meaning of what I intend to convey, I doubt whether I have put my name to an article in which it is stated that the production of carbonic acid in the actual electric furnaces is approximately equal to that of the retorts employed in the ordinary process.

On the contrary I have said (this journal, Vol. X, page 747): "This fact of the production of blue powder which does not take place in the ordinary retorts, or, if it does, in very small quantities, is due to the formation in the electric furnaces of a much higher percentage of carbon dioxide than in the usual retorts."

While I do not share all of Mr. Clerc's view, I agree with him as far as the influence of the cooling of zinc vapors, on the production of blue powder, is concerned. It is uncontested and a recognized fact that a too rapid or too intense cooling of these vapors gives rise to an excessive and sometimes total production of blue powder.

It is, in fact, this phenomenon which occurs in the electric furnaces when they are started, when care has not been taken to heat the condensers beforehand to the required temperature.

In such a case the phenomenon is even increased by the direct oxidation of the zinc vapors caused by the air contained in the condensers at the moment when it is set working.

The role played by the temperature in the condensation of the zinc vapors is well known to me and if I did not refer to it in the article on which Mr. Clerc comments it is that I considered this feature irrelevant to the subject I proposed to deal with.

In my article, in fact, I only intended to consider the present electric furnaces, their working and the manner in which they bring about the reduction of zinc ores. I left aside the condensation of the zinc which, after all, is only an accessory operation, very important no doubt, but which can and must be done easily if all necessary precautions are taken and if the reactions which release the zinc have been effected normally and without oxidation inside the furnace.

These indispensable precautions are principally the maintenance of the condensers at a temperature superior to that of the solidification of zinc (the most convenient appearing to be between 600° and 700° C.), and, as much as possible, the separation of the zinc vapors from other gases evolved by the reduction.

After this digression on the condensation problem, I regret to say that I am not at all of the opinion of Mr. Clerc as far as the reduction of zinc ores in electric furnaces is concerned.

Mr. Clerc seems to consider as a fairy tale the fact that the actual types supply a considerable proportion of blue powder. This is nevertheless so and all those who have experimented with electric furnaces agree in admitting that this notable proportion is produced, whatever thermal precautions may be taken to condense the zinc.

Mr. Clerc attributes the oxidation of zinc vapors in electric

furnaces solely to the presence of air entering the furnace by the open space around the electrodes. I also thought so previously, but having made experiments with a furnace in which this defect was eliminated I convinced myself that the oxidation was not due solely to the incriminated cause.

In the furnace I used (patent No. 989,169) the movable electrodes were fixed at the extremity of a round iron rod, which went through the furnace walls in an airtight joint in order to prevent absolutely the entrance of air. Notwithstanding said precaution, quite a notable amount of oxidation of zinc vapors took place, though of course in a lesser proportion than when ordinary electrodes are employed.

This led me to the conclusion that the proper working of the electric furnace was defective in itself and brought me to investigate the nature of the defects and their causes.

My investigations have been based on the following remarks: With arrangements as actually used, coal dust is found

FIGS. 1 TO 3.—SECTIONS OF ELECTRIC ZINC SMELTING FURNACE

even in the condensers; this could only be brought about by a strong outrush of gas and vapors which is caused by a too rapid reduction, and this in turn is the result of too high a temperature in a too limited space; there is inevitably an insufficient contact of the bodies in presence of one another. Therefore the reactions that should have existed between these bodies only take place in a very imperfect manner, and I was led to the conclusion that the defect stated was due, more particularly, to the great rapidity of the reduction and that to remedy the same it was necessary to provide the furnace with some means of considerably increasing the capacity of the active zone of reduction, while maintaining a moderate but sufficient temperature and as even as possible.

Though Mr. Clerc is of the opinion that such an improvement is of difficult realization, it appears to me that the aim has been attained in the furnace hereunder described and shown by the attached drawings (Figs. 1 to 3).

This furnace, as indicated, is operated by three-phase currents, but may be adapted to the use of two-phase or single-phase current or of direct current. It is made up as follows:

A, heating and charging chamber.

B, reduction chamber separated from A by partition P, which is provided with a central opening.

C, crucible chamber.

E E, set of shunted electrodes which can be connected, one apart, by interruptors J with phase 1 of the electric current.

E′ E′, set of shunted electrodes which can be connected by interrupters J with phase 2.

The electrodes E and E′ are not plunged in the charge, but simply placed in contact with it. The open space between the walls and the electrodes is filled up by an appropriate luting.

S, sole connected with phase 3.

J, interrupters to put in circuit, at will, the lateral electrodes E E′.

L, spout to draw the slag.

M, spout to draw the metals which are not volatile (lead, copper, etc.).

O, openings for the escape of gas and vapors.

R R′, lateral chambers, their object being to facilitate the condensation: First, by separating by different densities the zinc vapors from the reduction gases; second, by lowering the temperature of the zinc vapors to an intermediary degree between that of production and that of condensation.

P G, partition and angle iron destined to facilitate the escape of the gases and vapors.

H, pipe leading the zinc vapors into condensers maintained at a temperature of 600-700° C.

It is easy to convince oneself that the whole charge contained in the reduction chamber B of this type of furnace is crossed in all directions by the electric current and that all of said charge is maintained practically at a uniform temperature. This is regulated as required by means of the interrupters J which modify the number or the position of the electrodes put in circuit.

The experiments carried out with a furnace of this type gave excellent results in every respect: thermic efficiency, yields of metal, etc., the production of blue powder being 2 per cent, more or less.

If it is taken into account that this furnace eliminates the very defects which I pointed out as the causes of the bad working of the actual electric furnaces, it remains evident that the remarkable results obtained are the best arguments in favor of my assertions.

It is besides evident, at first sight, that the reduction should not be performed as quickly as possible, and that the minimum duration is limited by the obligation to obtain absolutely complete reactions. The experimental results are unanimous in demonstrating this fact. It is sufficient, in fact, in an electric furnace working under normal conditions to increase the density of the current to notice at once an increase in the proportion of the blue powder produced.

Mr. Clerc seems to admit that this excessive speed is advantageous because it reduces the losses in radiation and facilitates the condensation.

I am at a loss to see why the condensation should be rendered easier. On the contrary, it would seem that the production of too rapid reactions necessarily gives rise to the passage into the condensers, where their presence is pernicious, of all the gases resulting from these reactions.

As regards the profit realized by the losses in radiation, this is entirely imaginary. For this gain would be more than absorbed by the losses resulting therefrom, such as defective working, bad returns in metal, etc. Besides, even taking into account the losses only in radiation, I figure that on the basis of equal production, those of the ordinary electric types would

be at least equal, if not superior, to those of the above described furnace.

In conclusion, therefore, and notwithstanding the apparent value of Mr. Clerc's arguments, I consider myself justified in considering as correct the opinions given in my last article, not only because I consider them based on logical arguments, but more particularly because they are supported by practical experimental results.

These results can be verified by any one interested in doing so and it will afford me pleasure to furnish parties desirous of making new experiments, with a furnace of the described type, and all information they may like to solicit from me.

Like any discussion, it is to be hoped that this one will tend to bring some light on the electric treatment of zinc ores, and if such result is obtained it will be fair to give the credit to Mr. Clerc for the large share he took in it.

Mexico City, Mexico.   F. LOUVRIER.

The Western Metallurgical Field
Minerals Separation Flotation in Colorado

The first use of the Minerals Separation flotation process in Colorado is now under way at two places in the state, on two different classes of material. Earlier attempts have been made to introduce flotation processes in Colorado, but without success; the ores were not amenable to the methods used, and the ventures seem now to have been ill-advised. It appears, however, that the Minerals Separation process is to be successful, as the first results obtained are promising, and further familiarity with the process will enable its operators to improve their work.

One of the flotation machines is at work at Leadville, on the re-treatment of an old zinc tailings dump. This material has been tested before by various concentration processes, but has resisted successful treatment. It requires grinding to liberate the zinc mineral and the difficulty of saving this fine mineral has proved a stumbling block. The Minerals Separation process, however, is adapted to the recovery of finely divided mineral and is apparently proving successful. It is possible that some coarse concentration can be done, but most of the ore has to be tube-milled before treatment.

The other application of flotation is at Ouray, where original mine ore is being treated. The material is a mixed sulphide, containing pyrite, blende, galena and silver. The minerals are brittle and entailed heavy losses in ordinary wet dressing. The first work was done on fine pulp classified from the stamp-mill product, the coarse being treated on tables as before. It is understood that the flotation machine was successful in handling this product, and that the final design of the concentrating system is now under way. The product of flotation probably will be a mixed sulphide concentrate, requiring further separation, but as there is an electrostatic separating mill at Ouray, the flotation concentrate can be handled satisfactorily.

In connection with the fine grinding required in some instances to secure liberation of the mineral, the question of smelting finely divided zinc concentrate arises. Zinc smelters do not desire an undue proportion of fine concentrate, and in some cases exact a penalty based on a screen analysis of the material. But if the use of flotation brings an increasing quantity of fine zinc concentrate into the market, the smelter may find means of handling the material satisfactorily. The lead smelter has met a similar problem in blast furnace smelting by the use of the sintering machine, and possibly the zinc smelter also will be able to adapt himself to changes in zinc concentration.

Chloridizing Base-Metal Ores in Utah

Within the past year two announcements have been made concerning the use of chloridizing processes in Utah, but no technical or operating details have been made public. Interest has attached to these ventures on account of the fact that successful operators had given them approval to the extent of building plants for their application. One of these plants is at Park City, erected for the treatment of Ontario ore; the other is in course of construction in the Tintic district. The name of Niels C. Christensen, Jr., of Salt Lake City, has been connected with the development of the processes used at both places.

A possible hint as to the nature of the latter process is contained in specifications of a patent granted on October 7 to Mr. Christensen, in which he states that "the first 100-ton unit of a large plant is now in course of erection at Silver City, Utah, for the treatment of the ores of that district by this method." Disregarding for the time the apparatus by which the process is applied, details of which appear under Recent Metallurgical and Chemical Patents in the present issue, the steps in the proposed process are as follows:

The ore is mixed with the proper proportion of sodium chloride and pyrite, to give the chloridizing reactions, and ground to the proper fineness. It is then moistened with "mill solution," which is an approximately saturated solution of salts, $NaCl$, $MgCl_2$, and $CaCl_2$, and some HCl. It may be that no addition of sodium chloride to the ore will be necessary, as the saturated solution of chloride salts will carry sufficient chlorine to give the proper reaction. The per cent of solution will vary from 6 to 15 per cent. The moistened ore is then charged in a uniform layer from 3 to 18 inches thick on the revolving hearth of a furnace, where it is successively roasted, cooled and discharged. The hearth is perforated, and the ore charge is subjected to the action of hot air blown through the perforations.

The chloridized ore is then agitated with mill solution, and enough bleaching powder to dissolve the gold. The general result is that the gold is dissolved by the chlorine, the silver chloride by the other chlorides, the copper by the hydrochloric acid and the lead by the acid salt solution. This rich solution is filtered, and the residue properly washed, after which the metals are precipitated successively—the gold and silver on copper and copper and lead on iron.

The acid fumes from the roasting operations are recovered in a tower, being collected in some of the precipitated mill solution. Any volatilized metals also are thus recovered.

It is stated that numerous tests on different ores, both on a large and small scale, have given extractions as follows: gold, 80 to 95 per cent; silver, 80 to 96 per cent; copper, 75 to 98 per cent; lead, 80 to 99 per cent. The process appears to be a modification of the use of chlorine in extracting both base and precious metals from the same ore.

The Tariff on Ores and Metals

The passing of the Underwood tariff bill has finally shown the producers of ores and metals just what the import duties on their products will be for some time to come. With the new rates must come a period of readjustment to conditions, but it is not anticipated that any serious disturbances will result. The legal interpretation of some of the tariff items on ore must be awaited before we will know their exact meaning.

Following are some of the items of importance to western producers: Antimony, as regulus or metal, and matte containing antimony but not containing more than 10 per cent of lead, 10 per cent *ad valorem;* old rate on regulus and metal, 1½ cents per lb., and on matte 1 cent per lb. Antimony ore is on the free list, but only as to antimony content.

Copper in plates, sheets, rods, strips, pipes, and copper bottoms, etc., 5 per cent *ad valorem.* The old rate was 2½ cents per lb. Copper ore, regulus, cement, old copper fit only for remanufacture, and clippings from new copper, were placed on the free list.

Lead-bearing ores of all kinds, containing more than 3 per cent lead, ¾ cent per lb. on the contained lead. The old rate was 1½ cents per lb. Lead in bullion, pigs or bars, 25 per cent *ad valorem;* old rate 2⅛ cents per lb.

Zinc-bearing ores of all kinds, including calamine, 10 per cent *ad valorem* on the contained zinc. Under the old law these ores were free if containing less than 10 per cent zinc, and the rates were graduated up to 1 cent per lb. Zinc in

blocks, pigs or sheets, and zinc dust, 15 per cent *ad valorem*. Old rate, 1⅜ to 1½ cents per lb.

Nickel, its oxide, and alloys in which nickel is the constituent of chief value, in pigs, ingots, bars, rods and plates, 10 per cent *ad valorem*. The old rate was 6 cents per lb.

Quicksilver, 10 per cent *ad valorem;* old rate, 7 cents per lb. The following are on the free list: Platinum, unmanufactured, or made into apparatus for chemical use; plumbago; tin ore or metal, provided that a duty of 4 cents per lb. shall be imposed when the United States is producing 1500 tons annually of ore or metal; tungsten-bearing ores of all kinds, the old rate being 10 per cent.

Smelter Items

Some delay has been encountered in the installation of the Hall sulphur recovery process at the Balaklala smelter of the First National Copper Company, in California, and it is unlikely that operation will begin much before the close of this year. The anticipated success of this process means much to California smelting, which has been seriously hampered by the farmers' injunctions against the operation of smelters which discharge noxious fumes. The Hall process will produce sulphur as a by-product, and thereby eliminate this element from the smelter gases.

The Washoe smelter of the Anaconda Copper Co. was closed for about ten days early in October, for the purpose of making general repairs and a clean-up of the furnace-flue connecting with the main attack. The concentrator continued in operation as usual, treating Butte second-class ores; first-class ores were sent to the smelter at Great Falls.

Recent improvements at the Garfield smelter, Utah, consist in an extension of slag-dumping area by the construction of a steel bridge over the railroad tracks north of the plant, and in the erection of a new 350-ft. stack to supplement the present one which is 300 ft. high. All reverberatory furnaces at Garfield are now equipped for oil-firing, and are reported to be running satisfactorily.

The Arizona Copper Company produced during the month of September, 900 tons of copper. The output was considerably curtailed on account of the unexpected delay in getting the new furnaces in working order.

Goldfield Consolidated

The final report of this company's operations in August, 1913, shows that the total production was 32,096 tons of ore, the net realization from which was $198,784. The cost per ton of ore treated was as follows: Transportation, $0.07; milling, $1.85; marketing, $0.05; general expense, $0.03; construction, $0.01; total, $2.01.

The Non-Ferrous Metal Market

Dullness generally characterized the non-ferrous metal market in October. Demand has been light in spite of the tendency of producers to offer metal at lower prices. The copper producers are about the only ones to maintain asking prices in the face of no business, but the statistical position of that metal is such that buyers probably will come to sellers' terms.

Copper.—The situation in Lake copper remains unchanged and the quotations are practically nominal. Little business is being done, but producers seem content to await resumption of buying. Lake copper is quoted nominally at 16¾ to 17 cents; electrolytic at 16 to 16.10 cents.

Tin.—The domestic market has been dull and reduced prices have failed to stimulate buying. The London market also has shown a steady decline. October tin is quoted at 40¾ cents.

Lead.—This market has declined steadily throughout the month, following the action of the American Smelting & Refining Co. on October 1 in reducing its quotations. The last available quotations are 4.25 to 4.30 cents, St. Louis, and 4.40 to 4.45 cents, New York.

Spelter.—Toward the end of the month the concessions offered by sellers had the effect of stimulating some business in this market, but the buying was not heavy. There is, however, a stronger undertone and a more hopeful feeling. St. Louis spelter is quoted at 5.10 to 5.15 cents, and New York at 5.25 to 5.30 cents.

Other Metals.—The Aluminium market has been dull and prices are slightly lower at 20 to 20½ cents, New York. Antimony has been fairly active, with prices ranging from 6⅜ to 7.70 cents per pound. Quicksilver prices also are slightly lower, with a fair business transacted. New York and San Francisco quotations are the same, $38 per 75-lb. flask.

The Iron and Steel Market

October, usually a month of heavy buying, and of particularly large production through favorable weather conditions, failed entirely to live up to the precedents, as it witnessed a further decrease in buying, a more pronounced decline in prices and a diminished output of steel.

By the beginning of October a majority of the mills had reached a point at which the filling of old orders could not supplement the new orders currently received so as to maintain full production. The mills caught up with their orders and became able to ship on new orders and specifications within a few days. More strenuous competition for new business naturally resulted, with more active price cutting. A concrete evidence of the eagerness of the mills for business, even in very small orders is the fact that orders given to jobbers and to the distributing warehouses of certain mills, greatly decreased, because the buyers could purchase for direct shipment at regular mill prices.

Enough has now been developed to show clearly that the new tariff of October 4, 1913, is not directly the chief influence in the price decline. In few if any instances have mills lowered prices because the buyer put them in direct competition with foreign material. Prices are declining chiefly through the domestic mills being in competition with each other. One clear indication of this fact is that the price declines are as pronounced in the central west, which is altogether immune from foreign competition, as along the Atlantic seaboard, which is "exposed." To mention one commodity, the Pittsburgh and Philadelphia billet markets have always been independent of each other and the present experience is that billets have declined at least as much at Pittsburgh as at Philadelphia.

It is possible, however, that in a general way the tariff is responsible for decreased business activity in general, resulting in a smaller volume of demand, which in its turn causes a weakening in prices, so that indirectly the tariff is responsible for the present state of the steel market. The point to be emphasized is that at the moment there is not in progress a readjustment of prices with the cost of foreign material as the moving influence. Such buying as occurs is almost wholly for immediate shipment of small tonnages, involving orders that could not be placed abroad were the price ever so attractive. As the present readjustment proceeds a price level will probably be developed at which even large orders for extended delivery could not be placed abroad with advantage, except possibly in the case of a few commodities and in a few localities, to which foreign freights are low and freights from Pittsburgh are high.

On the basis of full rated capacity, which naturally can only be attained occasionally, under exceptionally favorable conditions, steel output has been approximately as follows: In the first half of the year, 95 to 100 per cent; in July, August and September, 90 to 95 per cent; on October 1, 90 per cent; on November 1, 80 per cent. A drop to 75 per cent by the end of November is far from improbable.

Opinions vary as to the probable duration of the present lull. The most hopeful view to be found is that a definite improvement will occur in three months, or by the beginning of February, while estimates run up to nine months. A factor to which the less hopeful probably do not give sufficient weight is that the country's steel-making capacity is relatively small considering the growth of domestic demand and the export trade. Additions to

capacity have been small in the past four years and very little new construction is now in progress. In previous depressions the common thought has been that time must be allowed for demand to catch up with capacity, but to-day no one can assert that there is an excess of capacity over normal requirements. Apart from all other considerations, the remarkable manner in which the mills were able to maintain substantially full production up to October 1, in face of extreme pessimism on the part of buyers and declining business activity generally, is evidence that the trade will pick up with unusual quickness.

Pig Iron.

Our review of a month ago noted that the fore part of September had shown a slight advancing tendency in pig iron prices, the latter part of the month showing a stagnant and stationary market. In October the condition developed into a definite declining tendency. Actual declines were confined to the Philadelphia and Valley markets, Buffalo, Cleveland and Chicago showing no change, while the southern market certainly lost tone even though it did not openly decline. During the first six months of the year pig iron declined, and by an average altogether of about $3.00 a ton, and while the advance to October 1 did not average much more than 25 cents a ton enough occurred to show that a definite upturn had commenced. This movement has had to yield to the generally unfavorable conditions, and particularly the declining tendency in steel products. The turnover in October was very light. Buyers' yards are bare and they have relatively little iron due on contract, while the merchant production has been greatly restricted and it is practically impossible for any important decline to occur. The market stands as follows: No. 2 foundry, f.o.b. Birmingham, $11.50; No. 2X, delivered Philadelphia, $15.75; No. 2X, f.o.b. Buffalo furnaces, $14; No. 2 foundry, delivered Cleveland, $14.75; No. 2 foundry, f.o.b. Chicago furnaces, $15; at valley furnaces (90 cents higher delivered Pittsburgh) Bessemer, $15.50; basic, $14; malleable, $14; No. 2 foundry, $13.75; forge, $13.50. Ferromanganese is $50, Baltimore, for prompt or forward, the price fixed by the English pool. German is sometimes offered at 50 cents less, but buyers frequently take the English material despite such a differential.

Steel.

As consumption of billets and sheet bars has decreased the ordinary contracts of consumers would easily cover their requirements, furnishing no occasion for much inquiry in the open market. As mills would sell at lower prices, however, each producer having a contract must protect it by adjusting the contract price or suffer the buyer to go elsewhere. The condition has led to wholesale readjustments, but as such readjustments can be made very quietly it is difficult to determine just what has been done, and the market can be quoted only approximately. It is quite certain that a fairly good buyer would not have to pay more than $22.50 for billets, $23 for sheet bars or $26 for rods, f.o.b. maker's mill, Pittsburgh or Youngstown, for either Bessemer or open-hearth. These quotations average about $1.50 below the nominal quotations mentioned a month ago.

Finished Steel.

In nearly all products the market has been a wide open one for several months, with prices on any given date varying according to the attractiveness of the order. During October the ordinary market has declined $2 a ton on tin plates, structural shapes and plates, and $1 a ton on wire products and sheets. Bars have not openly declined, but the old quotation of 1.40 cents is obviously only nominal in the circumstances. The average decline of all finished steel products from the top point is now fully $2 a ton. Ordinary open quotations, subject to shading in most cases, are as follows, f.o.b. Pittsburgh, unless otherwise stated:

Rails, standard sections, 1.25 cents for Bessemer, 1.34 cents for open-hearth, f.o.b. mill except Colorado.

Plates, tank quality, 1.30 cents.

Shapes, 1.35 cents.

Steel bars, 1.40 cents, base.

Iron bars, 1.55 cents, Pittsburgh; 1.25 cents, f.o.b. eastern Pennsylvania mill; 1.32½ cents, delivered Philadelphia; 1.20 cents, Chicago.

Wire nails, $1.60, base; plain wire, 1.40 cents, base.

Sheets, blue annealed, 10 gage, 1.50 cents; black, 28 gage, 2.00 cents; galvanized, 28 gage, 3.05 cents; painted corrugated, 28 gage, 2.20 cents; galvanized corrugated, 28 gage, 3.10 cents.

Merchant steel pipe, 80 per cent off list for ¼ to 3-in.

Steel boiler tubes, 3½ to 4½-in., 69 per cent off list.

Standard railroad spikes, 1.65 cents, Pittsburgh; 1.70 cents, Chicago.

Button head structural rivets, 1.85 cents.

Cone head boiler rivets, 1.95 cents.

Cold rolled shafting, 62 per cent off list, delivered.

Analyses of Anodes, Electrolyte, Wire Bar and Electrolytic Slime at the Great Falls Electrolytic Copper Refinery

In our September issue, p. 509, we gave an extended abstract of Mr. **Willis T. Burns'** excellent paper on the Great Falls Electrolytic Copper Refinery, presented at the Montana meeting of the American Institute of Mining Engineers.

To supplement the information given in our September issue, we give here the table of complete analyses of anodes, electrolyte, wire bar, and electrolytic slime, from Mr. Burns' paper. This table will be found exceedingly interesting, both by itself and in connection with the article in our September issue.

	Converter Anodes Per Cent	Electrolyte Per Cent	Wire Bar Per Cent	Electrolytic Slime Per Cent
Copper	99.1300	3.280	99.9500	43.3400
Arsenic	0.1183	0.500	0.0016	3.0300
Antimony	0.0534	0.041	0.0015	3.4600
Nickel	0.0420	0.377	0.0006	0.0800
Cobalt	0.0018	0.016	Trace	0.0060
Bismuth	0.0038	0.021	0.0004	0.1100
Iron	0.0110	0.600	0.0006	0.3640
Silver	0.1371	None	0.0030	17.1870
Gold	0.0008	None	Trace	0.1200
Selenium	0.0090	None	......	1.2000
Tellurium	0.0170	None	......	2.1000
Lead	0.0065	Trace	Trace	0.7600
Zinc	0.0035	0.418	0.0001	0.0900
Sulphur	0.2610	.....	0.0025	13.2100
Oxygen	......	.....	0.0350	....
Silicon	......	.....	......	0.1770
Chlorine	......	0.0040	......	0.0260
Carbon	......	.....	......	0.5900
Platinum	......	.....	......	0.000166
Free sulphuric acid	......	13.0300	......	......
Specific gravity	......	1.220	......	.....

New York Section of the American Chemical Society

The first meeting of the season of the New York section of the American Chemical Society was held in the Chemists' Building on October 10th.

The chairman of the section, Dr. B. C. Hesse, in his opening address, spoke with much common sense of possibilities of changing the method of presentation of papers at section meetings so as to elicit more lively discussion. Professor F. J. Pond presented then a long paper giving a historical review of the pioneer work on the synthesis of rubber which was discussed by various speakers.

Joint Meeting on Metallurgy of Zinc

A joint meeting of the New York Sections of the American Institute of Mining Engineers and of the American Electrochemical Society will be held at the Engineering Societies' Building, 29 West 39th St., New York City, on *Thursday*, November 20, 1913, at 8:30 P. M. The subject of the evening is the metallurgy of zinc, and the following papers will be presented:

Progress in the Metallurgy of Zinc. By George C. Stone.

Electric Smelting of Zinc Ore. By W. R. Ingalls.

Electrolytic Refining of Zinc. By Victor Engelhardt.

"Following these papers there will be a joint discussion of the subject. As there is much conflicting opinion on the future of zinc, it is expected that there will be much disorder."

Foundrymen's Convention and American Institute of Metals

Report of Chicago Convention

The annual conventions of the American Foundrymen's Association and of the American Institute of Metals were held in Chicago from October 14 to 17.

Mr. Alfred E. Howell, Nashville, Tenn., is the vice-president of the American Foundrymen's Association; Dr. Richard Moldenke, Watchung, N. J., was reelected secretary-treasurer.

The vice-presidents elected are: Messrs. R. A. Bull, H. A. Carpenter, S. B. Chadsey, G. R. Lombard, T. L. Richmond, T. W. Sheriff, J. J. Wilson, and Walter Wood.

At the last session a silver-loving cup and salver was presented to Past President Seaman, the first president of the Association and president of the Seaman-Sleeth Company, of Pittsburgh.

The banquet was attended by more than 300 men. There was no speech-making, but music and a cabaret and much gayety.

The exhibition of foundry equipment and machine tools again proved very attractive and was well attended.

Among the papers presented in the technical session were papers by W. S. Quigley on the use of powdered coal as fuel by F. T. Snyder on electric steel castings, by R. A. Bull on some difficulties in pouring steel castings, by E. L. Leasman on the annealing process for malleable castings by W. S. Hoyt on oxy-acetylene welding and cutting.

Notices and abstracts of some of them are reserved for a later issue.

American Institute of Metals

The Tuesday afternoon session of the American Institute of Metals was held jointly with the American Foundrymen's Association and was devoted to the presentation of a paper by Mr. M. W. Alexander on "an apprenticeship system in the metal industries," and a paper by Mr. C. E. Knoeppel on "how to make a time study."

APPRENTICESHIP SYSTEM

Mr. M. W. Alexander gave a very interesting outline of the scope and arrangement of the trade apprenticeship system of the General Electric Company and showed stereopticon views of the work done at Lynn, Mass.

The paper proved inspiring and was received with great interest. There is a general complaint of the difficulty of getting boys of any natural ability to enter the foundry trade. The need of an apprenticeship system for the metal industries is acknowledged to be very great.

HOW TO MAKE A TIME STUDY

Mr. C. E. Knoeppel, in the introduction of his paper, emphasized that the making of a time study is a most essential factor in any scheme of efficient management, and gave illustrations of the possibilities. The subject was then discussed under the following headings: Why time study is necessary; analysis of industry; the elements to be covered; variables of the man and the work; necessity for considering all factors; functions of time studies; tools needed; methods of making; studies as to classes; determining a fair standard; standardizing an operation; separation of inefficiency; detailed studies; making more than one study at a time; using regular watch with stop watch; correcting for errors; rest and fatigue; speeding the workers; practical uses of time study data; analysis sheet and schedule; organizing the work.

On account of the late hour, there was no discussion. That it was not on account of lack of interest, was proven by the Thursday session.

The attendance at this first meeting was somewhat disappointing. Both papers should have deserved a far larger audience. But many were kept away from the meeting proper by the exhibition and a desire to see men attending it.

REPORTS

The Wednesday session was opened by the presentation of the report of the official chemist, the report of the Bureau of Mines, and the report of the Bureau of Standards.

The report of the official chemists of the American Institute of Metals (Arthur D. Little, Inc.) was presented by Mr. C. F. Woods gave a concise review of the literature on metals and alloys, published during the past year. There was little discussion.

The report on the cooperative work of the Bureau of Mines with the American Institute of Metals was presented by Dr. Chas. L. Parsons. This comprises for the present the following four studies:

1. A comparative study of brass furnaces with particular reference to fuel efficiency and losses of metal in melting.

2. Study of the precautions to be taken for health and safety in the brass foundry.

3. The development of a suitable pyrometer for molten brass.

4. The development of an electric furnace for brass melting. H. W. Gillett has completed an extensive investigation of problems 1 and 2 and his comprehensive report is to be published shortly in bulletin form. Work is going on with two promising types of electric furnaces for brass melting.

The discussion showed a vastly increased interest in the use of the electric furnace for brass and bronze. Mr. Wallace, of the National Cash Register Company, emphasized the crying need of a pyrometer for use in molten brass—that is, a works tool, not merely a laboratory instrument.

The report on the cooperative work of the Bureau of Standards with the American Institute of Metals was presented by Mr. G. H. Clamer. This work is on test bars and the report gives a discussion of the results obtained to date at the Pittsburgh branch of the Bureau of Standards on gun metal, various forms of test bars, cast in green and dry sand, flat and upright, with and without shrink heads and at different pouring temperatures. The rate of cooling has a great effect. A remarkable sag in the pouring temperature-tensile strength curve is reported at a pouring temperature of 1150 to 1160 deg. C.

INTERNAL STRAINS

A paper by Mr. J. E. Howard reported on the magnitude of internal strains set up in brass, copper, etc., by peening the surface or bending. Strains as high as 15,000 lb. per square inch were reported. Further the release of all or part of the strains by annealing was shown. All this work was done on rolled bars, as preliminary to the projected work on strains in castings.

BUREAU OF STANDARDS

A paper by Dr. G. K. Burgess on "the work in metals at the Bureau of Standards," was made quite interesting by some forty lantern slides of apparatus shown.

One of the most important functions of the metallurgical division will be the preparation of standard chemical samples, metals and ores, to secure a uniform product not only for chemical standards, but also for pyrometric and metallographic purposes.

Regarding the work on non-ferrous standard chemical samples, the chief chemist of the Bureau, Dr. W. F. Hillebrand, was quoted as follows:

"The Bureau will soon issue a rolled brass carefully analyzed like its iron, steels and ores, for the purpose of checking analysis and their analytical methods. The preparation of a cast brass is also contemplated and, in fact, a sample was prepared and nearly ready for analysis, when it was inadvertently spoiled in the process of mixing. This unfortunate accident emphasized most strongly one of the difficulties encountered in the preparation of satisfactory samples of materials of the nature of this particular brass and of all others that are subject to segregation in the casting. This brass, containing 5 per cent of lead, became very dark colored during the operation of mixing in the machine specially designed for the purpose of mixing metal chips, and it was found that the lead alone seemed to have undergone marked oxidation. The sample had to be discarded and will not be replaced until some method of casting is devised that will insure the requisite homogeneity without mixing. Possibly the method of comminuting directly from the molten mass, as is successfully employed for solders and

other similar alloys, can be applied to brasses also, but thus far success does not seem to have been attained."

"The experience already gained at the Bureau shows clearly how extremely difficult it is to secure perfectly homogeneous samples of several hundred pounds weight and also how difficult it is for co-operating analysts to obtain agreeing analyses of samples that are homogeneous. I would emphasize in this connection the futility of sending out for co-operative analysis test samples which are not known positively to be entirely homogeneous, or at least sufficiently so to justify the expectation that the results obtained by different analysts will really furnish a true criterion either of the skill of the several analysts or of the reliability of the methods used by them. Before they are sent out for such comparative test by different analysts, the precaution should be taken to have each sample carefully analyzed by one competent man and by the same method, in order to ascertain if they all represent material that is really of the same composition."

"Given a material of satisfactory character there remains the fact, shown clearly by the experience gained at the Bureau during the past few years, that the art of analysis is yet far from being established on a satisfactory basis. Analyses by supposedly very competent men often vary widely. It has become evident that this disagreement is often due to lack of knowldge of the limitations of the method used or to disregard of minor, yet important, details in the analytical procedures that apparently can be overcome only by a closer study of some of the analysts of the errors that are often involved in their methods, errors of which they are seemingly unaware, or which they are inclined to disregard as unimportant. Often they are unimportant from the point of view of ordinary industrial needs, but the fact remains that when it is necessary to determine the composition with a high degree of accuracy, the analysts are too often unable to or do not apply the refinements that are necessary for the attainment of really precise results. It seems hopeless to expect great improvement in this respect by leaving the methods of procedure to the judgment of each analyst, hence arises the need for a very careful study of the comparative value of different analytical methods for a given material and of the most precise specification of the entire procedure to be followed for the method or methods that shall be found most suitable."

THE NOMENCLATURE OF NON-FERROUS ALLOYS

A second paper, by Dr. **G. K. Burgess**, of the Bureau of Standards, emphasized the need of a systematic nomenclature of non-ferrous alloys. Tentative suggestions were made as to the system. Nothing final, however, is to be done until the matter has been thoroughly gone into by the Bureau of Standards in cooperation with committees from various societies.

The discussion showed not only the willingness but the desire of the membership at large to reform the nomenclature in a rational way.

BRASS FOUNDRY OF THE FUTURE

This was the subject of the last paper on the program for the Wednesday session, by Mr. **C. P. Kerr**, of the Bureau of Standards.

The trend of his paper is indicated by the concluding remarks:

"The success of the brass foundry of the future will depend more upon the training of the man in physical and metallurgical science and his ability to apply his knowledge, than upon the machinery employed, desirable though it may be as an accessory to facilitate the production of his castings. In other words, the greatest possible factor for success lies in the development of the man himself."

SCIENTIFIC MANAGEMENT IN THE FOUNDRY

While the attendance had been better at the Wednesday meeting than on Tuesday, it was best of all on Thursday, showing the broad interest of the members in the subject of scientific management.

Four papers on this subject were presented and elicited much discussion proving that the brass founders present are making much more rapid advance in scientific management than is gen-

erally thought. Not a single word of opposition to scientific management was heard. All seemed agreed as to the desirability of standardizing conditions, planning and dispatching, of time and motion study and of some form of efficiency rewards by which the worker is allowed to make as high wages as he can without fear of a cut in wages, the price having been scientifically set by time study.

The discussion centered on the best ways of making workmen realize that the management would not cut the wages, and on the best wage system to award efficiency.

The discussion brought out in this session was considered to be so important that it was voted that it should be edited into coherent form and printed as a pamphlet in a sufficient number of copies to allow sending it to all interested, whether new members of the American Institute of Metals or not, on application to the secretary. Mr. W. M. Corse, Lumen Bearing Company, Buffalo, N. Y.

The four papers which elicited this spirited discussion were the following:

The Efficiency Engineer in the Foundry, by **E. A. Barnes**.

Preparation for Scientific Management in our Plant, by **W. M. Corse.**

How Scientific Management Works in our Plant, by **C. B. Bohn.**

Core Room Efficiencies, by **O. F. Flumerfelt.**

The discussion of the last paper mentioned showed increased interest in handling this generally neglected branch of foundry work on a scientific basis.

BOILING OF METALS

A paper on this subject by Prof. **Joseph W. Richards**, of Lehigh University, was the first on the program of the last session, held on Friday.

The author compared the evaporation of metals with the evaporation of water. He gave a very simple relation between the vapor tension curves of water and mercury. This is that mercury always boils at 1.7 times as high an absolute temperature as water, when they are boiling at the same pressure, whatever that pressure may be.

A general application of the same principle to other metals is suggested. This is possible if one definite point on the vapor tension curve of another metal is known, that is, one temperature for which we know accurately the metal's vapor tension.

"When we are told, for instance, that zinc boils at 930 deg. C. (1203 deg. A.), at normal atmospheric pressure, and we know that mercury boils at the same pressure at 357 deg. C. (630 deg. A.), then we say that the ratio of their absolute boiling points for equal pressures is $1203 \div 630 = 1.91$, and we use this ratio to construct the whole vapor tension curve of zinc from the known vapor tension curve of mercury. Or, we could equally construct it from the vapor tension curve of water, using the constant temperature ratio $1203 \div 373 = 3.2$; but it seems preferable to build on the mercury tension curve, because mercury is a metal, like zinc, and we feel a little more certain of our analogy when we compare the two metals."

The author also describes how to calculate the weight of metal vapor occupying a given volume at a given temperature.

PRODUCER GAS FOR BRASS MELTING

A long paper on "the application of producer gas to brass foundries," by Mr. **E. F. Bulmahn**, was next presented.

The following description of the equipment of the Langsenkamp-Wheeler brass plant, given at the end of the paper, is interesting.

Mr. Bulmahn's paper elicited considerable discussion. Five experiments now running in a yellow brass rolling mill indicate that producer-gas-fired furnaces give lower melting cost than coal or coke, but the metal losses are not reduced.

Rolling mill men present stated that they went through the producer gas game without success and are now looking to the electric furnace, since the mill conditions require an electric power plant anyhow and the added load comes cheaper. The reduction of the metal losses is the main point in favor of the electric furnace.

COMMERCIAL OPERATION OF THE HERING ELECTRIC FURNACE

Considerable discussion was also elicited by Mr. **G. H. Clamer's** paper on the Hering electric furnace (pinch effect furnace) in use in non-ferrous metallurgy.

The experience with a 20 to 30-kw. experimental furnace showed that about nine pounds of yellow brass are melted with one kilowatt hour. A large furnace is being erected which is expected to increase this figure to ten.

The power factor of the small furnace is 95 per cent, that of the large one 85 per cent or better.

During the development period much transformer trouble was experienced.

A new design of water-cooled electrodes is expected to minimize electrode troubles.

No difficulty is experienced in melting copper as well as brass, even though the resistance of copper is so much lower.

Three large Hering furnaces for brass melting are in course of construction.

SILVER PLATING AND SPOTTING-OUT

A paper by Professor **C. F. Burgess** and Mr. **L. T. Richardson**, of the Northern Chemical Engineering Laboratories, of Madison, Wis., deals with the trouble of "spotting-out" in silver plating. Attention is called to the fact that while potassium cyanide was formerly used almost universally by platers, sodium cyanide has been very generally substituted for it during recent years.

The authors produce evidence which is significant in that it suggests "a difference in properties as between potassium and sodium cyanides. The statements appearing frequently in the literature that sodium salts are less deliquescent than the potassium, and will for this reason cause less spotting-out, are evidently misleading.

"There is no doubt that the spotting-out problem is of sufficient importance to warrant even more careful investigation than has thus far been devoted to it and a part of this investigation should include a study of the relative influence of the sodium and potassium cyanides. We cannot base a definite conclusion upon the mere fact that pure sodium cyanide attracts moisture more readily than does the similar potassium salt.

"It is well known that during the operation of a plating bath the cyanides are gradually converted to carbonates. These carbonates may steadily accumulate in the bath, unless removed by the use of barium cyanide as a precipitating agent. Sodium carbonate is less deliquescent than is the potassium carbonate and we thus have a factor which may argue for the superiority of the sodium cyanide."

FLUXES FOR SOLDERS

A paper by Mr. **W. Arthur** dealt with "soldering fluxes for soft solder" and discussed the uses, advantages, and disadvantages of zinc chloride, an ammonium phosphate solution in water, lactic acid and ammonium lactate, resin either as powder or in alcoholic solution, citric acid solution in water, and ammonium chloride for fluxing purposes.

MELTING POINTS OF COPPER-ALLOYS

"The approximate melting points of some commercial copper alloys" was the subject of the last paper on the program, the authors being Messrs. **H. W. Gillett** and **A. B. Norton**. This is an investigation of the Bureau of Mines.

The chief results are given in Table I.

There was some further discussion of the Bureau of Standards report (presented on Wednesday) on test bars by Mr. Skillman.

A committee was appointed to confer with crucible makers with a view of standardizing sizes and shapes so that all makes work in all furnaces and fit all tongs. The difference in crucible sizes changes the fuel space in coke or coal furnaces and affects fuel efficiency.

The need of a practical pyrometer for brass melting became anew the subject of discussion.

NEW OFFICERS

Mr. G. H. Clamer, Ajax Metal Company, Philadelphia, Pa., is the new president of the American Institute of Metals. Mr.

TABLE I

	Composition Aimed at				Composition by Analysis				Melting Point (Liquidus)	
	Cu	Zn	Sn	Pb	Cu	Zn	Sn	Pb	C	F
Gunmetal	88	2	10	..	..	..	..	..	995	1825
Leaded gunmetal..	85½	2	9½	3	85.4	1.9	9.7	3.0	980	1795
Red brass	85	5	5	5	..	..(2 samples)..			970	1780
Low-grade red brass	82	10	3	5	81.5	10.4	3.1	5.0	980	1795
Leaded bronze....	80	..	10	10	..	..	..	..	945	1735
Bronze with zinc..	85	5	10	..	84.6	5.0	10.4	..	980	1795
Half yellow, half red	75	20	2	3	75.0	20.0	2.0	3.0	920	1690
Cast yellow brass..	67	31	..	2	66.9	30.8	..	2.3	895	1645
Naval brass	61½	37	1½	..	61.7	36.9	1.4	..	855	1570
Manganese bronze.	..	..	..	..	..	..	..	..	870	1600

W. M. Corse, Lumen Bearing Co., Buffalo, N. Y., was re-elected secretary-treasurer.

The following gentlemen were elected vice-presidents: W. H. Bassett, F. O. Clements, C. H. Ivey, Robert Job, J. L. Jones, E. Weintraub, F. Moerl, P. Mueller, C. A. Finnegan, E. S. Fretz.

Mr. H. W. Gillett, who had been in charge of arranging the very interesting program of papers for this meeting, was re-appointed chairman of the Papers Committee.

Iron and Steel Meeting of the American Institute of Mining Engineers

A very successful meeting of the American Institute of Mining Engineers was held in New York City on October 16 and 17, 1913, under the auspices of the Iron and Steel Committee. It was opened by the president of the Institute, Mr. Rand. He introduced the new chairman of the Iron and Steel Committee, Dr. Sauveur, who presided at the morning sessions of Thursday and Friday, while Dr. Richards presided on Thursday afternoon, and Dr. Raymond on Friday afternoon.

The meeting was exceedingly well attended, about 200 members being registered, and the luncheons between the morning and afternoon sessions were much enjoyed as they gave an opportunity for social intercourse.

On Friday night there was a dinner at the Engineers' Club while the Iron and Steel Committee held its dinner on Thursday night.

The morning session on Thursday was devoted to the reading and discussion of papers by W. A. Forbes on blast furnace gas cleaning; by W. H. Blauvelt on the slagging producer; by F. Peter on the generation of steam by waste heat from furnaces; by G. C. Stone on the generation of steam by waste heat from regenerative furnaces and by W. R. Shimer on over-oxidation of steel.

In the afternoon session of Thursday there was first an interesting discussion on the use of powdered coal as fuel introduced by three papers by Richard K. Meade, H. R. Barnhurst and E. W. Shinn respectively.

Then followed papers on briquetting, one by E. Stütz on the scoria process and the other one by F. A. Vogel and A. M. Tweedy on the Schumacher process, while a paper by R. H. Lee deals with the use of nodulized ore in the blast furnace. The latter paper was discussed at some length by J. E. Johnson, Jr.

The morning session of Friday was devoted to a very interesting discussion on metallographic subjects, the authors of the two main papers being Professor H. M. Howe and Dr. G. K. Burgess respectively.

The afternoon session of Friday was devoted to the discussion and reading of papers by R. R. Abbott, on the influence of various elements on the absorption of carbon by steel; by J. H. Hall on shock tests of cast steel; by G. H. Clevenger and B. Ray on the influence of copper upon the physical properties of steel; by J. H. Hall on the life of crucible steel furnaces; by H. F. Miller, Jr., on a new design of regenerators for open-hearth furnaces, and by W. E. Ruder on grain growth in silicon steel. On the whole the papers elicited an excellent discussion.

On account of limitations of space it is impossible to give a detailed report of the proceedings, but a summary of some of the more important results brought out in the various papers and discussions is reserved for our next issue.

Tests Upon the Transmission of Heat in Vacuum Evaporators.

Further Tests by Prof. E. W. Kerr

The issue of October, 1913, of the *Journal of the American Society of Mechanical Engineers,* contains a paper by Prof. **E. W. Kerr,** of the Louisiana State University of Baton Rouge, La., entitled "Tests Upon the Transmission of Heat in Vacuum Evaporators."

The general arrangement and the scope of the tests described in this paper are the same as described in Professor Kerr's former extensive researches, an illustrated account of which was given in our June, 1913, issue, pages 333 to 338. However, Professor Kerr's paper contains much that is new.

Tests were made with five different types of calandria. The first three types are those marked *B, C, D,* in Figs. 2 to 5 of page 334 of our June issue. The fourth and fifth types are new.

The fourth type (double-tube calandria) was built by Mr. T. F. Sanborn, of New York City, and is shown in Fig. 1. It is an evaporator of the steam-tube type with special arrangements for removing the incondensable gases.

There are two thick tube plates, one above the other, both of cast iron. The heating tubes, which are 2 in. in diameter and 54 in. long, are expanded into the upper tube plate. These tubes are closed at the top and are open at the bottom. Into the bottom tube-plate ⅛ in. tubes

FIG. 1.—TYPE E DOUBLE-TUBE CALANDRIA

are screwed. These small tubes are open at both ends and are placed inside of the heating tubes, reaching nearly to the top of the latter.

The space below the lower tube plate is connected to vapor space of the succeeding body in an evaporator of commercial size. Steam passes up into the heating tubes in the annular spaces surrounding the gas tubes, the incondensable gases being driven toward the top, from whence they are removed by the small gas tubes, each heating tube having its own individual incondensable gas remover. The lower tube plate is made saucer-shaped so that the condensed steam drains to the center, from where it is removed in the usual manner.

The fifth type (baffle-plate calandria) was built by Mr. A. L. Weber, of New Orleans, La., and is similar to types *B* and *C* (page 334 of June issue), with tubes 1¾ in. in diameter and 24 in. long, but differs from them in the manner of distributing

the steam to the heating tubes, and in the manner of removing the incondensable gases, the steam being supplied through four openings, one above the other, thus giving better distribution vertically. (Fig. 2 on page 612.)

Between the two tube plates a vertical baffle-plate is placed so as to guide the steam along a circuitous path to the 3-in. downtake at the center. This baffle-plate is so placed that the passage for the steam is gradually reduced in cross-section in order to keep the steam velocity as high as possible, overcoming to an extent the tendency to decrease the velocity due to condensation.

The incondensable gases are drawn off by means of a small perforated pipe through the top tube plate and reaching nearly to the bottom tube plate. The object of this design is to obtain high steam velocity among the heating tubes and effective separation of incondensable gases from steam.

That part of the evaporator above the top tube plate, which is called the vapor space, was 10 ft. high in all of the calandrias tested except that of Fig. 1, in which it was about 8 ft. This liberal height was provided in order to prevent, as far as possible, the carrying over of liquid in the vapors leaving the boiling surface.

As in Professor Kerr's former tests the object was to determine the effect of the following elements on evaporation: Effect of hydrostatic head, of temperature level, of incondensable gases, of density of liquid, and of type of calandria. These will now be considered consecutively.

Effect of Hydrostatic Head

Tests were made on four different calandrias in order to secure data on the effect of hydrostatic head. The results were plotted diagrammatically and for comparison the theoretical curves were also plotted according to calculations based upon the theoretical loss of temperature due to hydrostatic head. (The method of these theoretical calculations was given on page 334 of our June issue.)

Theoretically the coefficient of heat transmission decreases with increasing height of boiling liquid above lower tube plate. The results of the tests confirm this, but in all cases the loss in heat transmission due to hydrostatic head was considerably in excess of the theoretical, and the excess was greater for short tubes than for long tubes. The loss with varying heads, other conditions being equal, varies according to a straight-line formula.

The test curves seem to indicate that with tubes having the same length the rate of decrease in evaporation due to hydrostatic head is practically constant. But the curves for the 24-in. tubes are much steeper than those for the longer tubes (48 and 54 in.) showing that the effect of hydrostatic head is greater with short tubes than with longer ones. This is difficult to explain, although circulation doubtless has something to do with it.

Effect of Temperature Level

The total temperature fall in a multiple effect may be increased by increasing the temperature, or what is the same thing, increasing the pressure of the steam supplied to the first body, or by decreasing the pressure and temperature in the vapor space of the last body. It is evident that increasing the temperature fall, and therefore the capacity, by the first method results in increasing the average temperature in the heating compartments and that the second method results in decreasing it.

The relative advantages of high steam pressure in the first body as compared with high vacuum in the last body in obtaining increased heat transmission has been a matter of some question by many. Then, too, the reason for the inequality of temperature fall in the different bodies of a multiple effect, the greatest fall being always in the last body where the temperature level is lowest, is not definitely known, although it has been thought that the lowest steam density in the last body might be partly responsible.

In order to get data that would aid in settling these points a large number of tests were made. The results are given in tables and diagrams. The chief conclusion is as follows:
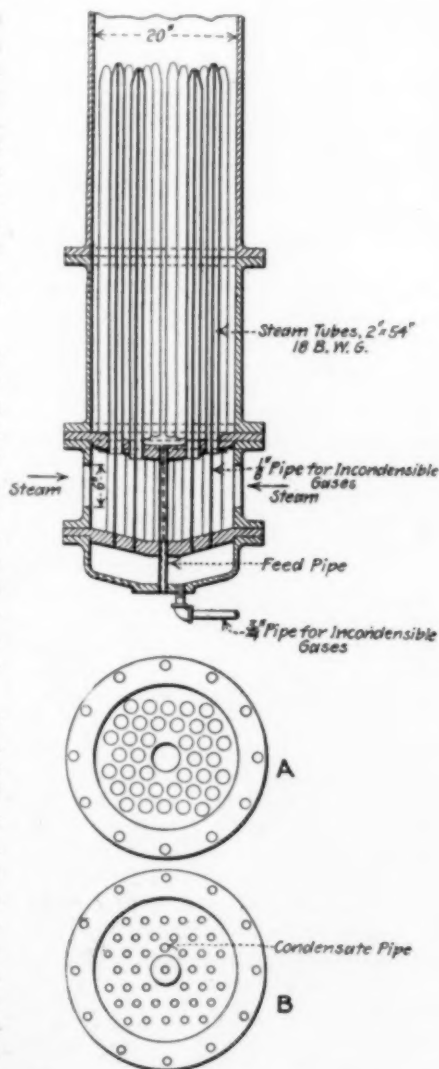
Other conditions being equal, the lower "the temperature level" the smaller the coefficient of heat transmission; in other words, the lower the temperature and density of the heating steam the smaller the coefficient. The coefficient U of heat transmission varies according to the equation

$$U = 2.25 + 17,500 \, D,$$

where D density of heating steam in pounds per cubic foot.

Effect of Incondensable Gases on Heat Transmission

The tests on this subject gave the following result:

Air or other incondensable gases in the heating steam greatly reduce the heat transmission, even with relatively low vacua. The coefficient of heat transmission U varies according to the equation

$$U = C \, (P_s/P_t)^n$$

in which C is a constant, P_s the partial pressure of the steam and P_t the total pressure. The presence of "air-pockets" may be conveniently determined by means of thermometers in the steam compartment; good circulation and distribution of steam are important in preventing them.

In the equation for the curve

$$U = (P_s/P_t)^n$$

the exponent n has a value of nearly 3, showing only a slightly greater decrease of the coefficient due to air than in the tests by George A. Orrok (*Transact. Am. Soc. M. E.*, Vol. 34, p. 713) on the subject of air in surface condensation in which the value of 2 was given to n. The absolute pressure in the evaporation tests was about 16.5 in. of mercury, whereas in the Orrok tests it was only about 2 in. These evaporator tests differed also from the condenser tests referred to as regards hydrostatic head and the range of the values of the coefficient of heat transmission. In the Orrok tests the maximum coefficient was only slightly above 300, while in the evaporator tests it was above 500. This latter was probably due to the greater steam density in the evaporator tests.

Attention has already been called to the fact that the evaporators shown in Figs. 1 and 2 were designed for the special purpose of overcoming the bad effects of incondensable gases. While it was practically impossible to determine the amount of air present, for the reason that the temperature existing adjacent to the heating surface could not be measured, the results obtained with these two arrangements show considerable improvement in heat transmission over those obtained from the others. The increase is doubtless due mainly to the more effective separation of air from the steam and to its prompt removal from the heating compartment.

Density of the Liquid

Increasing the density of the boiling liquid causes a loss in heat transmission due to the decrease in temperature fall. As the density is increased the boiling temperature increases according to the equation $y = CD^n$, in which C = a constant and D = density in deg. Brix. The total loss due to the density of the boiling liquid seems to be in excess of that due to loss of temperature fall. This is due to lower velocity of circulation.

FIG. 2.—BAFFLE-PLATE CALANDRIA

Last Body of a Multiple Effect

The great temperature fall required in the last body of a multiple evaporator is due to the combined influence of greater amounts of air, steam of lower density, liquid of higher density, also, in many cases, more foul heating surfaces than in preceding bodies.

Type of Calandria

The five calandrias tested differ from each other in several fundamental features. Most important among these differences
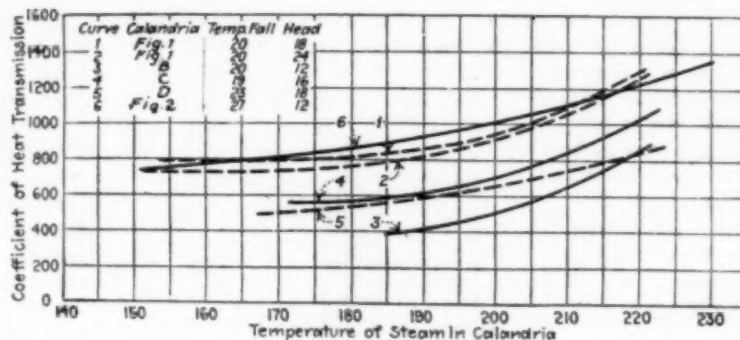
FIG. 3.—CURVES COMPARING HEAT TRANSMISSION IN DIFFERENT CALANDRIAS TESTED. CURVES 1 AND 2, CALANDRIA FIG. 1; CURVE 6, CALANDRIA FIG. 2; CURVES 3, 4, 5, CALANDRIAS B, C, D

of design may be mentioned proportions of tubes; that is, ratio of length to diameter, the use or non-use of downtakes to aid the circulation of the juice, and the methods employed for removing incondensable gases.

Comparative curves for the different calandrias are shown in Fig. 3. Curves 1 and 2 refer to the double-tube calandria shown in Fig. 1 in this article. Curves 3, 4, 5, refer to the standard types B, C, D, of calandria respectively, illustrated in our June issue, p. 334. Type C (curve 4 in Fig. 3) has a downtake, types B and D have not. Curve 6 refers to the baffle-plate calandria shown in Fig. 2 in this article.

Curves 3 and 5 show something as to the effect of varying the proportions of the tubes, the former for tubes 1⅜ in. by 24 in. and the latter for tubes 2 in. by 48 in., some advantage being shown for the long tubes, at least for low temperature levels. The greater heat transmission in the long tubes is probably due to better circulation. The greater the ratio of the length of a tube to its cross-sectional or carrying area, the greater will be the heat transfer per unit of carrying area, and this should increase the velocity of circulation.

A comparison of curves 3 and 4 shows a decided advantage for the downtake calandria over that without a downtake. The tests on the downtake calandria were made with a hydrostatic head of 16 in., whereas those on the other were made with a 12-in. head. Correction for this difference would slightly increase the advantage shown for the downtake calandria.

Curves 1 and 6 show the results of the tests on the two types of evaporators designed especially for efficient removal of incondensable gases. Both show coefficients of heat transmission considerably in excess of those obtained with the standard types represented by the curves 3, 4 and 5. Curve 6 for calandria of Fig. 2, the baffle-plate calandria with a head of 12 in., is only slightly higher than curve 1, which represents Fig. 1, the double-tube calandria with an 18-in. head. While the good results shown for these two calandrias may undoubtedly be attributed mainly to the more efficient separation of incondensable gases from steam and its removal, it is probable that the increased velocity of steam is also partly responsible.
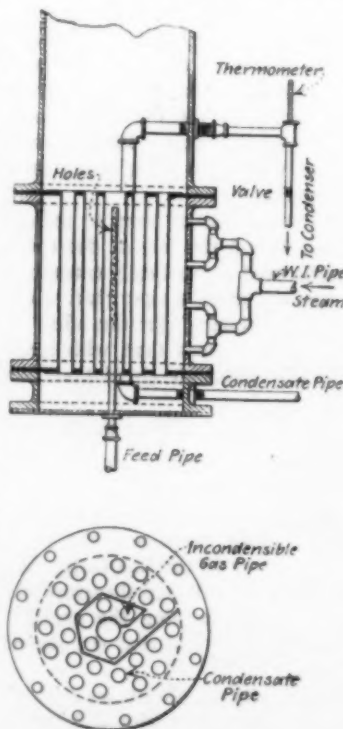
The Chile Copper Co. has an immense deposit of copper ore at Chuquicamata which consists mainly of brochantite, $CuSO_4 \cdot 3Cu(OH)_2$. The plan for treating this ore includes crushing to ½-in. size, leaching in vats with sulphuric acid, and electrolyzing the solution. The initial unit will have a capacity of 9000 tons per day.

0.5 Watt Per Candle Tungsten Lamps

Another Triumph of Physico-Chemical Research

At the meeting of the American Institute of Electrical Engineers, held in New York City, on October 10, 1913, two papers were presented on tungsten lamps of high efficiency. The first, by **Irving Langmuir**, dealt with "blackening of tungsten lamps and methods of preventing it." The second, by **Irving Langmuir** and **J. A. Orange**, with "nitrogen-filled lamps."

Both papers were presented by Dr. Langmuir. The presentation was accompanied by a series of most interesting experiments and demonstrations. These papers are printed in full in the October number of the *Proceedings* of the American Institute of Electrical Engineers, pages 1895 and 1915 respectively. We herewith give abstracts of both papers and comment on them on the editorial pages.

Blackening of Tungsten Lamps

The efficiency at which tungsten lamps may be profitably run is limited principally by the blackening of the bulb. It has usually been considered, especially among those most experienced in lamp manufacture, that the blackening of ordinary lamps was due very largely, if not entirely, to the presence of residual gases. The evidence which has led to this belief is discussed by Dr. Langmuir.

The sources of gases with the lamp were studied in detail. The principal gases are found to be water vapor, carbon dioxide, carbon monoxide, hydrogen, nitrogen and vapors of hydrocarbons. The specific effects produced by these and other gases were carefully determined by Dr. Langmuir. It was found that water vapor is the only one that produces perceptible blackening of the bulbs. The blackening by water vapor is due to a cyclic process in which the water oxidizes the tungsten and is itself reduced to *atomic* hydrogen. The tungsten oxide volatilizes and deposits on the bulb, where it is reduced by the atomic hydrogen to metallic tungsten and water vapor is again formed.

Attempts to materially improve the life of well exhausted lamps by the more complete removal of water vapor resulted, however, in failure. It is therefore concluded that, although water vapor is usually the cause of the short life of poorly exhausted lamps, yet it is not the cause of blackening in well exhausted lamps.

The real cause of blackening in well made lamps was proved to be evaporation of the filament, due to its temperature alone.

In order to test evaporation of the filament as the cause of the blackening, many experiments were undertaken to determine the rate of loss of weight of tungsten filaments when run at various temperatures in lamps. It was found that in lamps with filaments run at the same temperature the loss in weight was proportional to the surface of the filament and independent of the size of the bulb. The temperature coefficient of the rate of loss of weight was extremely high, as would be expected if it were proportional to the vapor pressure of the metal.

Furthermore, the actual measurements at various temperatures agreed remarkably well with the rational formula for vapor pressue

$$\log P = A - \frac{B}{T} - C \log T$$

From some simple considerations of the kinetic theory of gases, it became possible to calculate the actual vapor pressure of tungsten at various temperatures. It is of interest to give here simply the results at a few temperatures:

Efficiency, watts per candle	Temperature, absolute	Vapor Pressure, mm.
1.0	2400 deg. K.	0.000,000,05
0.4	2800	0.000,03
0.2 (melting-point)	3540	0.080
(boiling-point)	5200	760.

After it had been definitely settled that the blackening of tungsten lamps is caused by the evaporation of the filament a method of preventing the blackening is at once indicated.

This is the provision of a chemically inert gas in the blub, as it will tend to reduce the evaporation of the filament. Most gases react chemically with tungsten at high temperature, but hydrogen, nitrogen, argon, and mercury vapor seem to be chemically inert towards it.

Experiments showed that the evaporation of the tungsten in an atmosphere of hydrogen, nitrogen, or mercury vapor was indeed much reduced. But further experiments were necessary to determine whether the decrease in evaporation was sufficient to offset the loss of heat by convection from the filament through the inert gas.

With hydrogen the loss of heat offsets the benefit of reduced evaporation. The reason is that the heat of conductivity of hydrogen at very high temperatures is abnormally great, due to the dissociation of the hydrogen into atoms.

With nitrogen and mercury vapor it is different. The experiments indicated that the heat loss by convection increases at high temperature rather slowly with increasing temperature in the case of nitrogen and mercury vapors, though very rapidly in the case of hydrogen as stated. Further, the heat loss from very small wires, say 0.001 in. in diameter, is not very greatly different from that from wires several times this diameter. In other words, it is much more nearly correct to say that the heat loss by convection fom small wires is independent of the diameter, than to say that it varies proportionately with the diameter.

Tables were worked out which showed that the loss of efficiency (at constant temperature) due to the introduction of a gas at high (atmospheric) pressure is very much greater for filaments of small size, than for the larger ones, so that with wires of the sizes ordinarily used in lamps the temperature would have to be raised excessively in order to obtain an efficiency of even one watt per candle. Thus in nitrogen a filament of 0.0021 in. diameter (the size ordinarily used in a 20-watt, 110-volt lamp) would have to run at 3000 deg. to give one watt per candle. At this temperature of filament, the life of the ordinary lamp would be about 20 minutes, or about one fifteen-hundredth as long as that when running normally at one watt per candle in vacuum.

With filaments of larger diameter (0.005 in. and more), the loss of heat by convection is not nearly so serious, so that, if the rate of evaporation of the metal is very largely reduced by the presence of the gas, it is possible to raise the efficiency considerably without shortening the life.

The advantages of a large diameter filament can be practically obtained by coiling a smaller wire into a tightly wound helix or otherwise concentrating it into a small space.

Further experiments showed that the presence of the inert gas can be utilized in another manner. Not only does the gas decrease the rate of evaporation, but by proper design the course of convection gas currents can be directed along such channels that those parts of the bulb that are to transmit the light remain perfectly clear and any blackening deposit occurs on portions of the bulb where the blackening effect is of no account.

Nitrogen-Filled Lamps

In the second paper of which Irving Langmuir and J. A. Orange are joint authors, the authors state that by making use of the above principles they have been able to construct practical tungsten lamps which, starting at an efficiency of about 0.40 watt per candle, have run over two thousand hours, the average efficiency during life being better than 0.5 watt per candle. But such a degree of improvement has been reached only in lamps taking large currents.

Early experiments indicated the desirability of using a filament of large diameter. The larger filaments gave not only a better efficiency at any definite temperature, but also a much longer life. Thus doubling the diameter increased the efficiency from 0.65 to 0.56 and increased the life from 90 to 300 hours.

The improvement in the efficiency is due to the relatively smaller heat loss by convection from thicker wires.

The life of the filament is determined largely by the loss of tungsten from the filament by evaporation and depends on the *relative* decrease in diameter caused by this evaporation. If the rate of evaporation per unit area from large and small wires were the same, the lives of various filaments run at a given temperature would be roughly proportional to their diameters. However, as the evaporation of tungsten in nitrogen is largely a diffusion process, it probably obeys laws similar to those of conduction or convection of heat from a wire; that is, for wires of small diameter, the actual amount of tungsten evaporated would be nearly independent of the size of the wire. The rate of evaporation *per unit area* would thus be approximately inversely proportional to the diameter. The relative lives of very small wires in nitrogen are therefore nearly proportional to the squares of their diameters.

It is, however, not desirable to use filaments of very large diameter if similar results can be obtained with smaller ones.

Unless very low voltages are used, the power consumed with the larger wires is so great that only very high candle-power lamps can be made.

Therefore, it was of vital importance to increase the effective diameter of the filament without decreasing its resistance, and

FIG. 1.—HIGH-EFFICIENCY NITROGEN-FILLED LAMP FOR LOW VOLTAGE CIRCUIT

FIG. 2.—HIGH-EFFICIENCY NITROGEN-FILLED LAMP FOR LOW VOLTAGE CIRCUIT

FIG. 3.—NITROGEN-FILLED LAMP FOR 110-VOLT CIRCUIT

various methods of doing this were tried. The method which has thus far proved most satisfactory is to wind the filament into the form of a tightly coiled helix.

The use of a helically wound filament presents several very interesting features. The life of ordinary single loop filaments is limited by the irregularities in diameter which develop after a considerable amount of tungsten has evaporated. These irregularities, after they first appear, tend to magnify themselves very rapidly, on account of the tendency for the current to overheat any spot which becomes thinner than the rest of the filament. The overheating increases the rate of evaporation and rapidly causes failure.

In the gas-filled lamps, however, when helically wound filaments are employed, a new factor is introduced which entirely counteracts this tendency to overheat in spots. If, during the life of the lamp, any part of the filament should, for any reason, evaporate more rapidly than the rest, so that the filament becomes somewhat thinner, this portion will have less mechanical strength than the rest and will therefore sag more rapidly. The helix will therefore open out wherever the filament becomes thin or becomes overheated. This will cause

increased heat loss both by convection and radiation, and thus prevent local overheating or spotting.

The use of helically wound filaments increases the life of the lamp many times beyond the life that would be obtained with a straight filament running at the same efficiency. This is especially true of the smaller sizes of wire.

The authors then discuss the principles of the design of bulbs and locations of filaments.

In ordinary lamps about 20 per cent of the energy radiated from the filament is intercepted by the glass and causes heating of the bulb. In the nitrogen lamp, beside this radiated heat, there is an additional amount of heat carried to the bulb by convection—an amount varying with the type of lamp and ranging from 6 to 40 per cent of the total input. The convection currents carrying this relatively large amount of heat travel vertically upwards from the filament and strike a relatively small area of the bulb, which thus tends to become greatly overheated. Unless special precautions are taken, this overheating will cause the liberation of enough water vapor to cause attack of the filament and consequent blackening of the bulb. It is thus highly desirable, in ordinary cases, if small bulbs are to be used, that the filament should be placed in the lower part of the bulb. This has the further advantage that it allows sufficient surface of glass in the upper part for the deposition of the tungsten nitride.

For a similar reason it is generally desirable, although not necessary, to make the bulbs with their height considerably greater than their horizontal diameter.

By special design of the bulb, satisfactory lamps have been made with bulbs of only one-half to one-third as large a volume as that of evacuated lamps of the same wattage. This means that for bulbs of the same volume the nitrogen lamps give roughly from five to ten times the candle power of evacuated lamps. The bulbs of such lamps naturally run much hotter than those of ordinary lamps. The upper parts of the bulbs are often 100 to 200 deg. C. or more, while the lower parts are sometimes much cooler than this, although closer to the filament.

A few notes are given on lead-in wires and supports and it is mentioned that platinum has been discarded entirely, even in the smaller sizes. Mostly special alloys are used which have the same coefficient of expansion as the glass. Bulbs of special glasses into which tungsten or molybdenum wire can be sealed directly have also been used.

The principal limitations of the new type of lamp is that of current. There is no practical upper limit to the current.

For the particular type of nitrogen-filled lamp which has at present been furthest developed, it may be said that a life of over 1500 hours is obtained at efficiencies better than 0.50 watt per candle only in large units taking over ten amperes. Lamps running at 0.6 to 0.7 watt per candle have been made in units taking at least 5 amp.

A number of special types of nitrogen-filled lamps have been made as follows:

(1) *Large units of very high efficiency*, consuming 0.4 to 0.5 watt per candle with a life of 1500 hours or more. These take currents of 20 to 30 amp and (except in units over 4000 cp) are, therefore, best run from alternating-current circuits by means of small transformers or auto-transformers giving a voltage depending on the size of unit desired. Thus with 30 volts and 25 amp, the power would be 750 watts and this in a lamp of 0.45 watt per candle would give 1670 candle-power. Typical lamps are shown in Figs. 1 and 2.

(2) *Small units of low voltage* for street series lighting on 6.6-amp circuits (at 0.6 to 0.7 watt per candle), for stereopticon lamps and automobile headlights. These take currents of 10 amp or less at voltages as low as 4 or 5 volts. The specific power consumption with 1000-hour life ranges from 0.6 to 1.0, or even 1.25 watt per candle, according to the current used.

(3) *Lamps to run on standard lighting circuits* (110 volts). Large units of this type (of several thousand candle-power) consume 0.5 watt per candle or less.
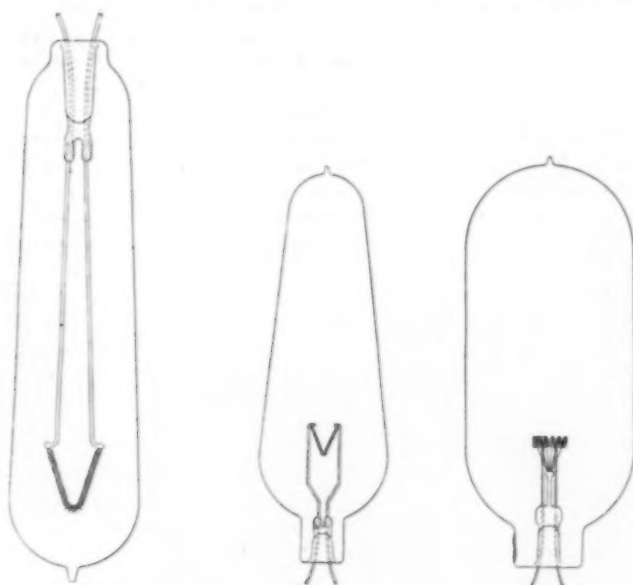
Special advantages of the nitrogen-filled lamps are:

1. Much whiter color of the light, due to the fact that the temperature of the filament is 400 to 600 deg. higher than that of ordinary lamps.

2. High intrinsic brilliancy of the filament.

3. Practical constancy of ampere-volt-candle-power characteristics during life.

The figures for specific power consumption given above are watts per horizontal (international) candles measured in the direction perpendicular to the plane of the filament if this is in the form of a single loop. Careful measurements have shown that with helically wound filaments the distribution of light in a horizontal plane is almost perfectly uniform, so that the figures for specific power consumption may be considered to represent also watts per mean horizontal candle.

The ratio of mean spherical to maximum horizontal (practically mean horizontal also) candle-power averages about 84 per cent for the lamps made with single loops of helically wound iron.

An appendix is added on methods of photometry of nitrogen-filled lamps.

Notes on the Standard Apparatus and Method for Measuring the Amount and Character of Atmospheric Pollution.

By John B. C. Kershaw

Observations with the standard apparatus and method of measuring the soot and dust fall of towns and cities (which were fully described in an article by the present writer in the issue of METALLURGICAL AND CHEMICAL ENGINEERING for June, 1913) commenced in October last in the following sixteen towns and cities: London, Hamburg, Birmingham, Glasgow, Liverpool, Manchester, Leeds, Bradford, Crewe, Exeter, Hull, Malvern, Leicester, Newcastle, Plymouth and York. As Hamburg has agreed to adopt the standard form of apparatus and method of collection, it is hoped that other German towns and cities will follow its lead, and that all the European records of atmospheric pollution, wherever obtained, may in time be based upon one uniform method of collection and examination.

The Department of Industrial Research in the University of Pittsburgh has been engaged also for some time past in an investigation of the smoke problem in America, and it would be a fitting close to the labors of the staff engaged in this research, if they could initiate a similar system of observation of the soot- and dust-fall in the more important cities of the U. S. A. The need for the adoption of a uniform system of collecting and examining the character of atmospheric pollution is proved clearly by the fact that all the observations yet made in different towns and countries are worthless for comparative purposes, since each observer has used a different apparatus or method and has applied it under different conditions.

In order that all interested in the subject of atmospheric pollution may be kept acquainted with the work of the London Committee, notes will be published from time to time in this journal, recording the progress made. The regulations which have been issued by the Central Committee for exposure of the gauge and for the chemical examination of the collected water and solid matter are given below. The standard soot- and dust-gauge was fully described and illustrated in the June issue of METALLURGICAL AND CHEMICAL ENGINEERING, and it is only necessary to state here for the benefit of those who did not read the earlier article, that the chief feature of the gauge is an enameled iron funnel with a superficial area of 4 sq. feet.

The gauges are to be placed, if possible, on the ground level, in open spaces free from abnormal dust. The bottles containing the water and deposit are to be removed on the last day of each month, and are to be replaced by thoroughly cleaned empty bottles. Before removing the bottles the gauge vessel is to be washed down with some of the collected water, a brush and rubber squeeze of standard pattern being used to remove any adherent matter. The chemical analysis of the water and deposit is to be made by a standard method (details of which are given below) and a report of the results obtained is to be sent monthly to the offices of the central committee.

The bottles properly labelled with the name and number of the station, and the period of collection, are to be kept standing in the laboratory for several days, until the insoluble matter has completely settled. The approximate volume of the water in litres should be ascertained at the time of the receipt of the bottles.

The undissolved matter is separated by filtration, the whole volume of collected water being used for this purpose.

The filtration is best effected in the following manner:—

A syphon-tube provided with a glass-tap or pinch-cock on the longer limb, is inserted into the bottle to within about one inch of the bottom. The bottle should stand at a height above the vessel in which the filtrate is to be collected, sufficient for an easy and adjustable discharge of the liquid. The filtering medium which has given the best results, consists of a layer of pulped filter-paper or of asbestos pulp suitably disposed in a Gooch-crucible. The Gooch-crucible should be fitted, by means of an adapter, in the rubber stopper of a graduated bottle of the same capacity as the station bottle. The rubber stopper of the second bottle is also provided with a tube leading to a vacuum pump. The filter is prepared with the pulp in the usual manner, and the filtration takes place under moderate suction. Should the filter become clogged, the pulp, together with any solids collected upon it, may be removed to a porcelain basin and kept for further treatment, while a new filter is made from fresh pulp.

After the clear portion of the liquid has been filtered, the bottom turbid portion may be shaken up and syphoned over into the Gooch-crucible,—the bottle is then washed out with some of the filtrate. Any pulp left over or previously removed, is finally put on top of the solid matter collected in the crucible. Should there be more than one station bottle, it is best to filter first the clear liquid of all, and then the portions containing the solids which have settled.

The Gooch-crucible, after its contents have been washed with distilled water, and dried at, 105°C. is weighed: the gain in weight equals the *total insoluble matter*.

The crucible is then placed in an extraction apparatus, and the contents are extracted with carbon bi-sulphide. The loss, after drying, represents the *tarry matters*.

The residue in the crucible is then ignited in a current of air until all the carbonaceous matter is burned away. The residue equals the *ash* or *mineral constituents* of the insoluble matter of atmosphere.

In order to determine the amount of dissolved matter 250 cc. of the filtrate are evaporated to dryness on a water-bath: the residue is then dried and weighed—this gives the *total dissolved solids*.

The loss on gentle ignition gives the *organic matter soluble in water*; the residue represents the *soluble inorganic matter*.

For the determination of *sulphates* one liter of the filtrate is concentrated, and acidified with hydrochloric acid. The liquid is then boiled. Barium chloride is added, and the precipitated barium sulphate at the end of twelve hours, is filtered off—washed, dried and weighed.

The *chlorides* are estimated by titration of 500 cc. of the filtrate with N/10 silver nitrate solution, taking the usual necessary precautions to ensure the absence of carbon-dioxide (or carbonates) in solution.

The *ammonia* is determined by acidifying 1000 cc of the filtrate with dilute sulphuric acid, and after concentrating the solution to 100 cc. and making strongly alkaline, distilling the residue into a measured amount of N/10 acid. The excess of acid is then determined by titration with N/10 alkali, and the amount of ammonia present is calculated from the acid which has been neutralized and has thus disappeared.

The *lime* is precipitated as calcium oxalate in 1000 cc. of the filtered water, and is weighed as calcium oxide (CaO).

The *alkalinity* (or *acidity*) of the filtered water is determined

on the usual quantity by means of N/100. hydrochloric acid (or N/100. sodium-hydrate solution) using methyl orange as indicator. The acidity is to be caluculated as sulphuric acid,—the alkalinity as ammonia.

Eleven results for each monthly sample of the rain-fall will in this way be determined,—two of these representing the totals of the Insoluble and Dissolved matter, and the remaining nine being the chief constituents of the solid matter brought down with the rain.

As an example of the results obtained with this method of observation, the figures published on page 340 of our issue of
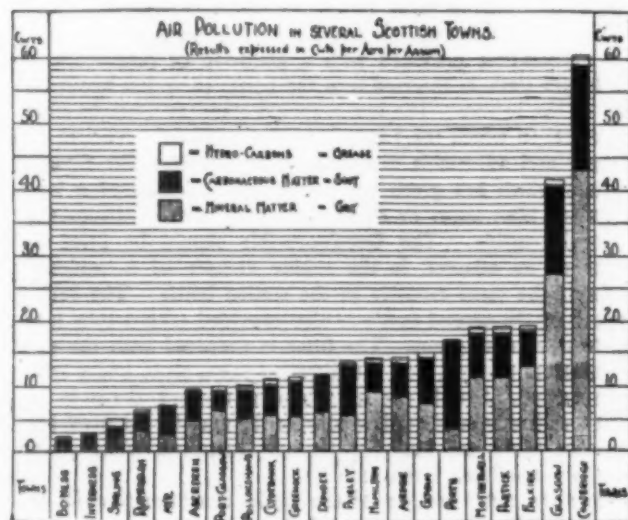
FIG. I.—DIAGRAM SHOWING THE CONJUNCTIVE SOOT AND DUST FALL OF SCOTCH TOWNS IN TEN WINTER MONTHS OF 1910-1911

June 1913 may be referred to. These showed a total fall of soot-and-dust in the London area ranging from 195 tons per sq. mile per annum at Sutton in Surrey to 650 tons per sq. mile per annum in the center of the City of London.

As a second example, the figures obtained by Chief Inspector Fyfe in Scotland may now be quoted. These are given in Tabular form in Table I. and in diagramatic form in Fig. I. The method of collection used by Inspector Fyfe, namely, shallow wooden boxes—one foot square in superficial area and one foot deep, was however less exact than that used for the London observations, and it is quite possible that when the Standard apparatus and method is adopted in Scotland by other towns and cities than Glasgow, somewhat different results will be obtained.

It must be pointed out also that Inspector Fyfe's observations extended only over the two mid-winter months of the years 1910 and 1911, and that owing to the greater amount of coal burned in Winter, and to the greater carelessness of stokers and furnacemen during the long hours of darkness, both the smoke from domestic and industrial chimneys is enormously increased at this period of the year. An average for the whole year calculated on the soot and dust-fall of the two winter months, is therefore misleading and inaccurate.

The continuous records which will be obtained by the standard apparatus and method will, of course, be free from this defect, and it will be of interest to see how the soot-and dust-fall of Glasgow compares with that of Manchester, Leeds, and other great English centers of manufacturing industry, when the first twelve months period of observations has been completed, and the returns are all in.

In concluding this account of the work that has already been achieved, some extracts may be given from the appeal for funds which has been issued recently by the Committee.

"The co-ordination of observations is the legitimate work of "a Committee. The design of new apparatus and methods for "carrying out any particular inquiry may properly be left to indi-"vidual effort, but the selection of a method for the special work "of comparison,—the specifications of common conditions,—and

"the co-ordination of the results,—are essentially matters for co-"operative action and can only be carried out by a represen-"tative body.

"The Committee is now faced with the necessity for finding "funds to carry out the work which will devolve upon it, when "the scheme of co-operation commences. It is proposed that "the several localities shall provide their own apparatus, and "also make the analyses of the collected products. But when "that has been done, it will still be necessary for the Central "Committee to collect and arrange the records and distribute "the information acquired to those who are interested in the "subject, and this involves a considerable amount of secretarial "work with its incidental expenses. Further, a number of "questions of detail will certainly arise, with regard to the "apparatus used and the methods of analysis, and these can "only be answered by means of experimental inquiry.

"The Committee have no claim upon the funds of any exist-"ing Society, and that they should personally bear the costs of "the inquiry, goes beyond the terms of the Resolution which ap-

TABLE I. AVERAGE AIR POLLUTION IN SEVERAL TOWNS IN SCOTLAND FOR THE WINTER MONTHS OF 1910-1911 (Fyfe)

Town	Mean population, 1901-11	Mineral matter	Carbona-ceous	Hydro-carbons, matter	Total	Tons per sq. mile
Bo'ness	10,086	1.35	.31	.09	2.27	72
Inverness	22,645	1.38	1.31	.27	2.96	94
Stirling	19,801	2.52	—2.50—		5.02	160
Rutherglen	21,502	3.30	2.84	.56	6.71	208
Ayr	30,841	2.68	4.35	.25	7.28	233
Aberdeen	158,293	4.78	4.85	.24	.9.87	315
Port Glasgow	17,303	6.55	2.90	.58	10.03	320
Pollokshaws	12,037	5.52	4.01	.62	10.15	325
Clydebank	29,224	5.76	4.49	.97	11.22	350
Greenock	72,025	5.80	5.08	.82	11.70	374
Dundee	163,994	6.17	5.53	.20	11.90	381
Paisley	81,920	5.91	7.26	.62	13.79	441
Hamilton	35,709	9.25	4.37	.60	14.22	455
Airdrie	23,338	8.61	4.81	.93	14.35	459
Govan	85,960	7.65	6.69	.65	14.99	480
Perth	34,923	3.58	13.34	.39	17.31	554
Motherwell	35,761	11.47	6.83	.97	19.27	616
Partick	60,573	11.37	6.98	1.19	19.54	625
Falkirk	31,424	12.99	5.77	.86	19.62	627
Glasgow	780,028	27.03	13.54	1.04	41.61	1330
Coatbridge	40,139	42.96	15.97	1.66	60.59	1939

"pointed them. They therefore appeal to the public for funds "and especially for annual subscriptions in order that the work "now set on foot may be continued, and are confident that the "importance of trustworthy knowledge of the state of the at-"mosphere as regards impurity justifies them in making this "appeal."

The author's thanks are due to Chief Inspector Fyfe of Glasgow for permission to make use of the diagram and table giving the results of the interesting observations made in Scotland. A full account of these observations will be found in a paper contributed by Chief Inspector Fyfe to the Manchester Smoke Abatement Conference of 1911.

Liverpool, England.

The Murex magnetic concentration process has been applied successfully to both sulphide and carbonate ores. The crushed ore is mixed and agitated with an emulsion of oil and magnetic oxide of iron, after which it is passed under an electromagnet which lifts the particles which have been coated with the emulsion. The process has been used at the Cordoba copper mine in Spain, and the Whim Well copper mine in Australia. At the latter place, carbonate ore is treated, producing a concentrate of 20% to 25% copper from 6% ore, and yielding a recovery of about 80%.

The Growth of the World's Copper Mining Industry in the Years 1898-1912

By John B. C. Kershaw

There is probably no industry that can show such a remarkably rapid rate of expansion during the past quarter of a century as that of copper mining. Taking the average price of the metal produced during this period as £60 per ton, the aggregate annual value of the output of copper by all the mines of the world, has increased from £15,480,000 in 1898, to £60,-024,000 in 1912, or by nearly 400 per cent.

In fact, if the aggregate value of the copper produced in 1912, be calculated on the basis of the average price obtained for bar copper in that year (namely £73 per ton) the astonishing total of £73,290,000 is obtained as the present value of the annual output of the copper mining industry. These totals prove that the industry is only second to that of gold-mining, in the value and importance of the metal produced.

The figures used in preparing the tables and diagrams which illustrate this article, are taken from the valuable monthly and yearly statistical circulars prepared by Messrs. H. R. Merton & Co., of London, to whom the writer's thanks are due, for permitting their carefully compiled returns to be used in this way.

AGGREGATE PRODUCTION OF COPPER BY ALL THE COUNTRIES OF THE
WORLD IN THE PERIOD 1898-1912

Table 1 and Fig. 1 give the statistics showing the rapid growth of the world's copper mining industry in the fifteen years ending in 1912.

TABLE I—TOTAL WORLD'S OUTPUT OF COPPER—1898-1912

Year	Output in tons	Increase or decrease
1898	429,262	29,896
1899	472,244	42,618
1900	479,514	7,270
1901	516,628	37,114
1902	541,295	24,667
1903	574,775	33,480
1904	644,000	69,225
1905	682,125	38,125
1906	714,100	31,975
1907	713,965	(—,135)
1908	754,180	40,215
1909	839,425	85,245
1910	864,275	24,850
1911	871,920	7,645
1912	1,004,485	132,565

The variations in output from year to year are seen to have been very irregular, ranging from a decrease of 135 tons in 1907, to the enormous increase of 132,565 tons for the year 1912. The increase for the whole period is however very striking, for the output of copper has more than doubled in the period under review, and the rate of increase, if averaged over the 15 years, gives an annual rate of increase of 40,000 tons or 5.5 per cent. Ten years ago an output and consumption of 1,000,000 tons of copper in one year would have been regarded as incredible, but the 1,000,000-ton mark has now been exceeded, and the demand for the red metal still grows, if present
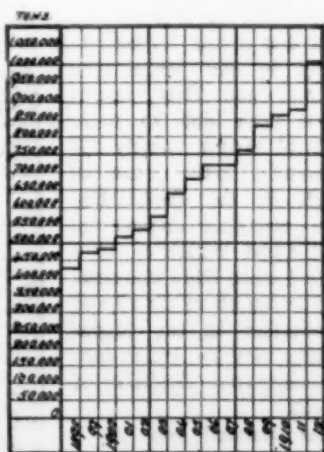
FIG. 1.—THE WORLD'S COPPER PRODUCTION

prices can be accepted as any criterion of the real demand.

THE RELATIONSHIP BETWEEN THE WORLD'S TOTAL OUTPUT OF COPPER AND THE PRODUCTION OF THE U. S. A. MINES

Table II and Fig. 2 illustrate the relationship between the American copper production and that of the remaining countries of the world, and are useful as showing clearly the predominating position occupied by the U. S. A. mines. The output of these mines in 1912 amounted 554,835 tons, and the percentage of the total output provided from this source, worked out to 55.4 per cent. This figure agrees closely with 15.5 per cent in 1911, and proves that in spite of the large aggregate increase in production during the past year, the advantageous position occupied for so many years by the U. S. A. mines, is still maintained.

TABLE II—RELATIVE PRODUCTION OF COPPER BY THE MINES OF THE
UNITED STATES AND THOSE OF OTHER COUNTRIES—1898-1912

Year	U. S. A. Mines Tons	Percentage	Other Countries Tons	Percentage
1898	234,271	54	195,355	46
1899	262,206	55	210,038	45
1900	263,502	55	216,012	45
1901	265,250	51	251,378	49
1902	292,870	54	248,425	46
1903	307,570	53	367,205	47
1904	365,050	56	278,950	44
1905	389,120	57	293,005	45
1906	409,650	57	304,450	43
1907	392,520	55	321,445	45
1908	423,300	56	330,880	44
1909	490,280	57	349,145	43
1910	484,935	56	370,750	44
1911	483,865	55	388,064	45
1912	554,835	55	449,650	45

This advantage is clearly indicated in Fig. 2, and it can be seen that the margin between the aggregate output of the U. S. A. mines and that of all other countries, is widening instead of diminishing. This paramount position of the U. S. A. mines in the copper mining industry undoubtedly enables the American financiers to exercise a control over the supplies of the metal and to regulate prices, but this is outside the scope of this article to discuss.

THE COPPER OUTPUT OF THE TWELVE MORE IMPORTANT COUNTRIES IN THE PERIOD 1898-1912
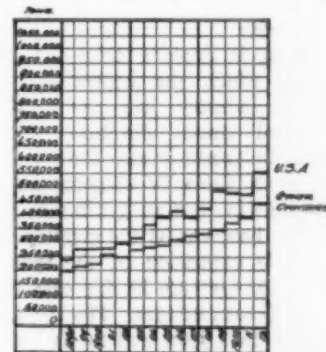
FIG. 2.—AMERICAN COPPER PRODUCTION

Tables III and IV and diagrams III and IV give the production figures from Messrs. H. R. Merton's returns, for the twelve more important countries (excluding U. S. A.) for the fifteen years ending 1912. Although these twelve countries have greatly increased their aggregate output of the metal during the period under review, their proportion of the total output has remained stationary, at slightly under 45 per cent.

These twelve leading countries rank in the following order of importance as copper-producing countries, when judged by their output of the metal in 1912; Mexico, Japan, Spain and

TABLE III—THE COPPER OUTPUT OF THE LEADING PRODUCING COUNTRIES
(EXCLUDING UNITED STATES OF AMERICA) FOR THE PERIOD 1898-1912

Year	Mexico	Japan	Spain and Portugal	Australasia	Chili	Canada
1898	16,435	25,175	52,375	18,000	24,850	8,040
1899	19,335	28,310	52,168	20,750	25,000	6,730
1900	22,050	27,840	52,872	23,020	25,700	8,500
1901	30,430	27,475	53,621	30,875	30,780	18,800
1902	35,785	29,775	49,790	28,640	28,930	17,485
1903	45,315	31,360	49,790	29,000	30,930	19,320
1904	50,945	34,850	47,035	34,160	30,100	19,185
1905	64,440	35,910	44,810	33,940	29,165	20,535
1906	60,625	42,740	49,320	36,250	25,745	25,460
1907	56,565	48,935	49,675	41,250	26,685	25,615
1908	39,990	43,000	52,585	39,500	38,315	28,570
1909	56,325	47,000	52,185	34,400	35,785	24,105
1910	61,515	46,000	50,255	40,315	35,235	25,715
1911	60,905	55,000	50,930	41,840	29,595	24,930
1912	70,845	65,500	58,930	47,020	37,305	34,710

Portugal, Australasia, Chili, Canada, Russia, Peru, Germany, Africa, Norway, Servia. The figures for many of these countries exhibit the striking progress of the copper mining industry during the period under review Japan, Mexico, Russia, Australasia, Canada, and Peru showing extraordinary developments of this industry.

Mexico which in 1898 produced only 16,435 tons of the red metal, produced 70,845 tons in 1912, and has permanently displaced the Spanish Peninsula, from its place of importance as

a copper-producing country. The Mexican mines are controlled chiefly by American financial interests, and the output varies considerably according to the state of the copper market. In recent years a large number of old mines have been reopened and worked again, but these are closed down when the price of copper falls below a renumerative level.

Japan has shown steady progress as a copper-producing country during the past fifteen years, and has increased its output from 25,175 tons in 1898 to 65,500 tons in 1912, thus ranking third in the list of producing countries.

Australasia and Canada. —The copper mining and smelting industries in these two countries have also shown notable expansion in the period covered by the table—the Australasian output having increased from 18,000 tons in 1898 to 47,020 tons in 1912, and the Canadian figures showing an increase from 8104 tons to 34,710 tons.

Russia is another country in which the copper mining industry has experienced great developments in recent years, the figures in Table IV showing an advance in production from 6260 tons in 1898, to 33,010 tons in 1912.

FIG. 3.—MAJOR COPPER PRODUCING COUNTRIES OTHER THAN THE U. S. A.

Peru, however, is the country which can show the most remarkable expansion of the industry during the past fifteen years, the increase in this case being from 3040 tons in 1898, to 27,165 tons in 1912. The output has, however, remained stationary since 1910, and the inference is, that the copper mines of Peru have about reached the upper limit of their productive capacity. Otherwise the great rise in the price of copper that occurred during the years 1911-1912, should certainly have brought about an increased ouput in the latter year.

Chili, which so long ago as 1897 produced nearly 50,000 tons of copper, is once again increasing her production, and has advanced from 24,850 tons to 37,305 tons in the period covered by Table III.

Africa has advanced her output from 7110 tons in 1898, to 16,370 tons in 1912, and when the ores from the much talked-of Katanga mines, north of the Zambesi river, are being smelted on a large scale, a notable addition to the copper exports of this part of the world may be expected. At present the smelters erected in the Zambesi district are not working satisfactorily, the restricted fuel supply having created greater difficulties than was anticipated.

Servia is a new addition to the ranks of the producing countries, and although the Servian mines only commenced to produce copper in 1908, their output in 1912 amounted to 7,240 tons. The Balkan war will, however, have stopped all development here for the present year.

The old established copper mining industries *in Spain and Portugal* and in *Germany* do not show any figures for its ex-

pansion similar to those given above. The aim of those governing the production of the copper mines situated in these countries, is well known to be that of maintaining a steady output, rather than to force production and exhaust the ore reserves, during the successive short periods of high prices.

Figs. 3 and 4 show clearly the rapid expansion of the copper mining industry in ten out of the twelve countries, during the period 1898-1912, and summarize in graphic form, the information as to progress given above.

VARIATIONS IN VALUE FOR THE PERIOD 1898 TO 1912, AND THE RELATIONSHIP BETWEEN OUTPUT AND PRICE

The figures showing the average price of standard bar copper are given in Table V., which also contains the figures for the world's total output of copper in each of the years named. Fig. 5 gives

FIG. 4.—MINOR COPPER, PRODUCING COUNTRIES

these figures in graphic form, and it will be noticed that the "curve" for the price variations, shows three periods of high

TABLE V—THE WORLD'S OUTPUT OF COPPER COMPARED WITH THE AVERAGE PRICE OF "STANDARD" METAL, FOR THE PERIOD 1898-1912

Year	Total Output	Average Price. Per ton		
		£	s	d
1898	429,626	51	7	10
1899	472,244	72	10	6
1900	479,514	73	19	7
1901	516,628	67	17	3
1902	541,295	52	13	5
1903	574,775	57	18	8
1904	644,000	58	14	8
1905	682,125	69	2	6
1906	714,100	86	5	2
1907	713,965	87	1	8
1908	754,180	60	0	6
1909	839,425	58	17	3
1910	864,275	57	3	2
1911	871,920	55	16	2
1912	1,004,485	73	1	3

prices with three depressions. The price boom of 1898 to 1899 was due to the formation of the Amalgamated Copper Company in the States, the second and third booms have been due to more natural causes, namely the extremely active state of trade in the shipbuilding and electrical engineering and allied industries, at a period when there was some slackening off in the rate of production in the copper mining industry, and in consequence some depletion of stocks.

As pointed out by a writer in the London *Times* recently, activity in the shipbuilding industry creates a great demand for copper, and "if the man-in-the-"street or the speculator in "copper-warrants were to "make an exhaustive exam-

FIG. 5.—COPPER PRODUCTION AND PRICES

"ination of a first-class high-speed ocean liner, he would be "amazed at the quantity of copper, plain or as brass required "about her engines, her auxiliary plant, her sanitary arrange-

TABLE IV—THE COPPER OUTPUT OF THE MINOR PRODUCING COUNTRIES (EXCLUDING UNITED STATES OF AMERICA) FOR THE PERIOD 1898-1912

Year	Russia	Peru	Germany	Africa	Norway.	Servia
1898	6,260	3,040	20,085	7,110	3,616	....
1899	7,210	5,165	23,460	6,490	3,610	....
1900	6,740	8,220	20,410	6,720	3,935	....
1901	8,000	9,520	21,720	6,400	3,375	....
1902	8,675	7,580	21,605	4,450	4,565	....
1903	10,320	7,800	21,205	5,230	5,915	....
1904	10,700	8,755	21,045	7,775	5,415	....
1905	8,700	8,625	22,160	7,740	6,305	....
1906	10,490	8,505	20,340	6,980	6,120	....
1907	15,000	10,575	20,490	6,800	7,010	....
1908	20,085	15,000	20,200	6,880	9,190	2,140
1909	17,750	16,000	22,455	14,945	9,080	4,480
1910	22,310	26,945	24,710	15,205	10,425	4,845
1911	25,310	28,050	22,010	16,980	9,420	6,885
1912	33,010	27,165	23,920	16,370	10,980	7,240

"ments, her kitchens, her saloons, staterooms, and staircases, "even her portholes, rails and scuppers."

The estimated consumption of copper in 1912 was 1,024,000 tons. The stocks were reduced by 20,000 tons between January and December 31, in that year, and the output amounted, as already stated, to the huge total of 1,004,000 tons. How long the mines of the world can continue to supply copper at this rate is a question, the answer to which only the future can disclose. There will undoubtedly come a time, however, when the suplies of ore of the red metal will become exhausted, and when copper will appreciate in value owing to this cause. It will then be the duty of the chemist and metallurgist to provide a satisfactory substitute for the metal which has so long occupied a foremost place in the metal industry of the world, and it will no doubt be found that *aluminium* or some of the *aluminium alloys,* can be used for many of the hundred and one purposes, for which *copper* is now universally employed.

Liverpool, England.

Applications of the Microscope to Industrial Work

The season's first meeting of the New York section of the American Electrochemical Society was held on October 17 at the Chemists' Building and was very enjoyable and successful. The attendance was large, the big lecture hall being almost completely filled. Although the meeting lasted well beyond 11 o'clock, the attention of the audience never lacked.

Great credit is due to the chairman of the section, **Mr. Lawrence Addicks,** superintendent of the U. S. Metal Refining Company, of Chrome, New Jersey, for having arranged an exceedingly interesting program. The subject of the evening was the application of the microscope to industrial work. All the papers were profusely illustrated with most instructive and in part brilliant lantern slides. As it is a physical impossibility to reproduce here the many microphotographs shown, it is rather difficult to do justice to the meeting in this report.

The Metallography of Carbon

The first paper was presented by Professor **G. A. Roush,** of Lehigh University. In an investigation of the internal construction of carbon products and of the kinds of raw materials suitable in their manufacture, success was obtained by the application of the ordinary principles of preparing samples of metals for metallographic examination. The ordinary metallographic methods proved satisfactory also for carbon products, with the exception that some special means of etching were required to bring out the structure of the sample, since the acids used for this purpose with metal samples do not attack carbon. Relief polishing, used as with metals, proves satisfactory in some cases; this is secured by polishing the sample on a soft, yielding surface, such as broadcloth, so that the soft parts of the sample are worn away, leaving the harder parts in relief.

For ordinary work, etching with heat gave good results. A sample, after being polished, was heated to a low red heat until the oxygen of the air had attacked the polished surface just enough to dull it a little, and then the sample was cooled in a blast of air. This oxidized the softer parts of the sample faster than it did the harder parts, and thus developed the structure. Samples of carbon treated in this way showed the individual grains of which the body of the material was composed, the thin films of binder holding these grains together,

and the pores between the grains. A sample can then be judged in regard to its porosity, and in regard to the size and shape of the grains from which it is made up. The size and shape of the grains will be found to vary widely with the method of crushing, and the porosity varies with the grain size and the pressure under which the material has been formed into shape.

By carrying matters a step further, and examining samples of the various raw materials used it was found that the more important of these showed a characteristic structure, so that the individual grains of sample from an unknown source could be identified. When this was found to be possible, the methods of measurement of microscopic particles used in petrography were made use of, and in this way, approximate quantitative analyses of materials could be made. A known sample, containing 33 per cent of petroleum coke by volume, showed by analysis 32 per cent.

Carbon electrodes which had been converted into Acheson graphite showed the outlines of the individual grains of the raw material, and frequently showed the characteristic structure of the raw material. Whether this retention of the original structure was due to incomplete conversion into graphite, or whether it was analagous to a pseudomorphous crystal, was not determined.

The examination of fine powders under the microscope sometimes can be greatly facilitated by moistening with a very dilute solution of gum arabic, pressing together firmly, smoothing off a surface with a spatula, drying, and then examining the grains making up this smooth surface.

Professor Roush's paper was illustrated by numerous lantern slides showing photomicrographs of characteristic structures.

Micrometry as Applied to Alloys

A paper on this subject was then presented by Dr. **C. H. Mathewson,** assistant professor of metallurgy at Sheffield Scientific School, Yale University.

In a general sense, methods in which the microscope is used are termed micrographic methods; when applied in a rigidly quantitative sense they are termed micrometric methods. The discussion in the first part of the paper is based on the Al-Zn system, as recently revised by Rosenhain and Archbutt.

The conditions represented in an earlier diagram of Shepherd were very simple. According to it no intermediate phases are formed, but both aluminium and zinc crystallize as solid solutions, aluminium dissolving some 45 per cent of zinc and zinc dissolving several per cent of aluminium at the eutectic temperature. The eutectic mixture contains 5 per cent of aluminium.

Rosenhain and Archbutt's later diagram, based on very accurate and delicate measurements, is of considerable complexity. This is mainly associated with the presence of an intermetallic compound $Al_2 Zn_3$ which escaped the attention of earlier observers as it is formed in most of the alloys by reaction between a primary crystalline phase, rich in aluminum and residual solution containing about 85 per cent Zn, with little evolution of heat.

In this investigation the errors due to incomplete reactions became evident. Thus the primary crystals may be enveloped by a layer of compound as it first forms, and the cores of the crystals are thus protected from further change. Rosenhain and Archbutt emphasize the caution which must be used
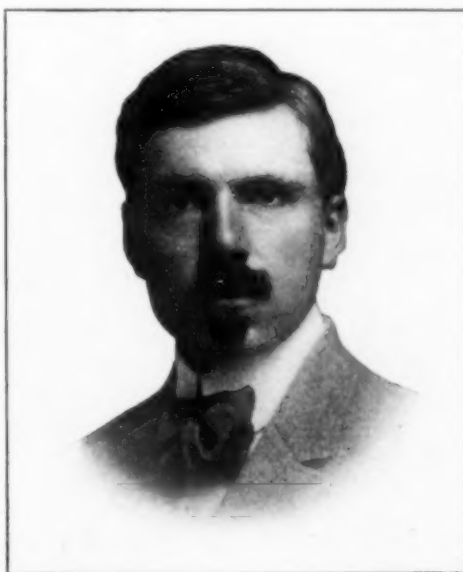
LAWRENCE ADDICKS, CHAIRMAN NEW YORK SECTION
AMERICAN ELECTROCHEMICAL SOCIETY

in applying the method of thermal analysis, owing to the possibility of incomplete adjustment of equilibrium during the brief period of time in which all observations are made. This possibility must be considered in all cases where it is desired to interpret micrographic evidence quantitatively, since any change in solubility, any chemical reaction or other variety of transformation involving crystalline phases, is likely to proceed incompletely, particularly if it occurs at a fairly low temperature.

By annealing their alloys at a temperature slightly below the peritectic horizontal, Rohenhain and Archbutt were able to prevent envelopment and conduct the reaction quantitatively.

In addition to the qualitative interpretation of photomicrographs, as authors commonly apply theme in a semiquantitative sense. In the present case, having established the fact that the reaction may be rendered complete by annealing at a suitable temperature, it is obviously in order to seek the concentration at which both reacting phases are completely exhausted in forming the compound by examining a series of micrographs. When this result is attained there will be no residual eutectic to be seen in the alloy. Rosenhain and Archbutt show a photomicrograph in which a much smaller quantity of the white constituent is to be seen. This alloy contains 80 per cent zinc and is evidently very close to the composition of the pure compound. In a third photomicrograph, corresponding to 77 per cent zinc, no eutectic is to be seen. We cannot conclude that this is the exact composition of the compound, since it forms solid solutions with an excess of Al, but, it is clear that the pure compound lies between 77 and 80 per cent zinc, and, according to the thermo-analytical results, the eutectic disappears at 78.8 per cent. The formula $Al_2 Zn_3$, requires 78.35 per cent. The different results are quite sufficiently in accord. There appears to be no reason why we may not make use of these photo-micrographs in a rigidly quantitative sense. The structure-elements appearing in them are zinc, containing about 1 per cent Al, according to the authors, and $Al_2 Zn_3$, both, probably of invariable composition under the present thermal treatment. It is true however that the composition of the zinc-rich phase should be more thoroughly investigated for these purposes. When this point is settled and when we have ascertained the relative densities of the two constituents, we are in a position to calculate the actual percentages of each constituent by weight from area measurements on the photo-micrograph.

Assuming that the equilibrium diagram is available in correct form, we are thus able to calculate the percentage of Al or Zn present in any alloy within this part of the diagram by properly annealing the alloy, preparing a representative section, examining it under the microscope, and photographing a typical portion of the surface, or tracing it directly from the screen to save time. It is, of course, highly important to sample the metal carefully in the first place, as in ordinary analysis. This may be done in the usual way, by taking drillings or chips from different parts of the specimen if the may be melted down easily without change in composition. It is better to take a few coarse pieces from different parts of the specimen and melt them down under a flux. With low melting metals, this may be done as rapidly as the ordinary process of sampling and solution. In this method of analysis, a second important process of sampling or selection occurs under the microscope. At this point, the whole surface should be examined carefully and a thoroughly representative spot chosen for the graphical treatment.

While, in most investigations, the formulas of intermetallic compounds and other fundamental concentration values have been located by thermal analysis, it is quite as feasible to use the micrometric results in a similar manner, i. e., instead of represented eutectic periods of constant temperature as ordinates at the various concentration points and extrapolating concentrations at which a zero or maximum period occurs, we may represent the percentage area of eutectic in the different concentrations as ordinates and extrapolate in the same manner. This possesses an advantage over the thermo-analytical

method in that it is not necessary to use the same volume or weight of metal in the different determinations (cf. Tammann, Z. anorg. Chem., 45, 292, 1905).

Dr. Mathewson has used Rosenhain and Archbutt's photomicrographs in this way with the following results: The area of the white constituent in the 80 per cent Zn alloy, determined with the polar planimeter, is 25.6 per cent of the whole; in the 77 per cent Zn alloy, it is 8.3 per cent. Assuming a linear decrease in the volume percentage of the white constituent, with the concentration (expressed in terms of Zn and $Al_2 Zn_3$), the zero value obtains at 78.1 per cent Zn. That this result agrees almost exactly with the true composition of the compound $Al_2 Zn_3$, 78.35 per cent zinc, must be regarded as fortuitous, since the photo-micrographs were not selected by the authors with a view to micrographic work and, the planimetric measurements were not made on specially large scale drawings.

In using the planimeter on the 77 per cent Zn alloy the isolated white areas were joined to one another in the manner suggested by Sauveur ([1]). The tracing pin was then moved over portions of the area boundaries in one direction and returned over the remaining boundaries following the connecting lines in the reverse direction, so as to nullify their original effect on the reading.

In practically all metallographic papers, we find semiquantitative deductions based upon some of the photomicrographs. But Dr. Mathewson points out that it is dangerous to rely upon general appearances instead of actual measurements of area, even though approximate. In this case, a calculation based upon the equilibrium diagram shows that the eutectic should contain 19.4 per cent of the compound by weight. When treated so as to reach equilibrium below 256 deg., there is a possibility that the areas corresponding originally to compound will be still less, owing to decomposition of the compound and its replacement by the Zn-rich phase and another Al-rich phase, some of the former probably coalescing with the original light constituent. We do not know the densities of the two constituents, and cannot calculate the area which should correspond to the above percentage by weight, but it is certainly true that not more than one-third of the whole area is occupied by the dark constituent in photomicrograph. Rosenhain and Archbutt's photomicrographs of the slowly cooled eutectic. This conclusion was reached by tracing the outlines of the dark constituent upon finely ruled co-ordinate paper, estimating the number of squares included within these outlines, and calculating the total number as a percentage of the whole. As a result of two separate measurements, 28.6 and 29.2 per cent of the area is found to represent the compound.

It is clear that the relation between the squares and the individual areas to be estimated may be chosen so that a relatively large number of squares are entirely included within an individual area, leaving a comparatively small portion of the area open to errors of measurement. In many cases, this method of measurement will be found more convenient and probably more accurate than the plenimetric method. By comparison, such methods are cutting out the separate images and weighing the paper, or measuring the portions of a straight line intercepted by the different constituents, are laborious or inferior in point of accuracy. This method may be applied very rapidly by tracing the outlines of the constituent in question upon a thin sheet of co-ordinate paper upon which the image is focused through a clear glass plate at the back of the camera. The author has made some determinations of iron in spelter in this manner at the Hammond Laboratory of the Sheffield Scientific School.

Previous investigation has shown that iron crystallizes from zinc in the form of beautifully developed individuals containing from 7 to 11 atoms of zinc per atom of iron. This represents a case very favorable to the development of a micrometric method of analysis, since some 13 times the weight of

[1]Trans. Am. Inst. Min. Eng., 26, 880 (1896).

the added element, iron, is clearly visible as a distinct structure element. This case was discussed in some detail by Dr. Mathewson.

Probably more attention has been devoted to the determination of various elements entering into eutectic relations with copper than to any other micrometric problem. Heyn (*Zeit. L. anorg. Chem.*, vol. 39. p. 1, 1904) first demonstrated the structural relations brought about by the solidification of copper containing oxide and introduced a method of determining the oxygen content by area measurements. It is now recognized that this method is sufficiently reliable to be of practical value and far more convenient than any chemical method, although area measurements of eutectic structures in the presence of a primary constituent are likely to give variable results, and the exact quantitative effect of impurities, such as As, Sb, etc., has not been determined. According to this method, the relative areas of eutectic and primary copper crystals are determined by measurement, planimetric or otherwise, on the micrograph. The eutectic is composed of 3.45 per cent cuprous oxide and 96.55 per cent copper, according to Heyn. Since one unit of oxygen by weight corresponds to 8.95 units of cuprous oxide, which in turn correspond to 28.99 units of eutectic, the oxygen is represented in the micrograph by a distinct structure element 261.46 times its own weight. We may make errors of several per cent in estimating the weight of the eutectic by area measurements without seriously affecting the results as expressed in oxygen.

Hofman, Green, and Yerxa have determined the oxide in samples of refined coper by using the planimeter on enlarged micrographs (magnified 1150 diameters) and by analysis, according to Hampe's method. Bardwell has described the use of a similar method at the Great Falls smelter and gives comparisons with ordinary analytical data which clearly indicate the value of the method in technical practice. Dr. Mathewson has used the micrometric method of determining oxide in cast copper with students in the Department of Mining and Metallurgy at the Sheffield Scientific School for several years.

Huntington and Desch have tested the micrometric method of analysis very fully in the case of copper-phosphorus alloys which also contain the non-metallic element in the eutectic condition. In this case, the eutectic is composed of copper crystals containing 0.175 per cent phosphorus in solid solution and copper phosphide, Cu_3P, the total composition of the mixture being 8.27 P + 91.73 per cent Cu. The amount of phosphorus held in solid solution by the copper appears to be constant in the cast and annealed alloys. A very different factor, however, renders the ordinary planimetric determination of the phosphorus content by measuring the eutectic areas very inaccurate. This lies in the variable composition of the metal surrounding the primary copper crystals. Normally this should be of definite (eutectic) composition, but during the cooling of the alloy subsequent to eutectic crystallization, or during the annealing, the small copper crystals of the eutectic have coalesced with the large primary crystals in the immediate vicinity and the phosphide has also coalesed around the enlarged copper crystals. It is evident that the eutectic no longer contains 91.73 per cent Cu if we measure it from the boundaries of the black crystals, but somewhat less than this. Huntington and Desch were able to correct the measured areas of the black srystals with surprising accuracy by measuring the area of the enveloping belt of phosphide and deducting the amount of eutectic copper normally corresponding to this phosphide from the black crystals. When the phosphorus content is low the net work of eutectic is originally fine and, as a result, all of the copper coalesces with the large crystals leaving a pure phosphide network.

In the micrometric treatment of eutectic structures great care must be taken to recognize and allow for coalescence. In some cases, it is practically absent as in copper-phosphorus alloys containing copper phosphide as a primary constituent, i. e., those high in phosphorus. There also appears to be relatively little interference of this sort in the copper-copper oxide alloys previously discussed.

In forecasting the future possibilities of micrometric methods, Dr. Mathewson pointed out that we must be mindful of the fact that the microscope offers primarily a means of studying the proximate composition of metallic material and that the direct results obtained in this manner can be translated into ordinary analytical results only in favorable cases and under closely regulated conditions. It is, therefore, more logical to expect future development to lie principally in the direction of interpreting and applying the proximate results themselves in the estimation and specifications of quality, without regard to chemical compositions, except within prescribed limits. It is conceivable that, in many cases, it may be far more important for the manufacturer to know that his product conforms to a certain standard in respect to size of crystals, percentage of area occupied by inherent crystalline phases, or micrographic character in general, than to possess elaborate analytical detail concerning the ultimate composition.

It appears more desirable to record the micrometric results directly in terms of the structure elements measured, and seek to make full application of them in this form rather than to attempt the calculation of ultimate composition from them. For example, the character of the copper-cuprous oxide eutectic is influenced by the presence of arsenic. In the absence of precise information on this point, it does not appear desirable to calculate the oxygen in an arsenical copper under the assumption that the eutectic contains 3.45 per cent. Cu_2O. It seems better to record the percentage area of primary copper crystals along with qualitative data regarding the appearance and distribution of the eutectic.

Obviously, it is impossible to draw any deduction concerning the ultimate composition of an alloy composed of a homogeneous solid solution from micrometric results. It is a matter of common practice, however, to control the heat treatment of such alloys by measuring the size of the crystals or counting the number present in a given area under given magnification.

Dr. Mathewson concluded that we have in micrometric analysis a valuable aid in the scientific or technical examination of alloys, which is often superior to ordinary analysis as regards the character and extent of the information returned, but which ordinarily constitutes a source of distinctive results rather than a substitute for ordinary analysis. A satisfying total of analytical information is obtained by judiciously combining the two methods.

Microstructure of Raw and Manufactured Copper

A really remarkable series of microphotographs was shown and discussed in a paper of Mr. **W. H. Bassett**, Technical Superintendent and Metallurgist of the American Brass Company of Waterbury, Conn.

The microphotographs shown indicated the changes in structure due to working copper, that is, they showed the differences between copper in the cast and wrought condition.

The pictures also showed clearly the influence of the oxygen which is always present in copper, upon its structure, both in the cast and wrought condition. The presence of the copper-copper suboxide eutectic is readily distinguished microscopically, and several quantitative methods have been devised for determining the amount of oxygen in the copper by the aid of the microscope.

Certain impurities in the copper, such as antimony, modify the character of the eutectic, and their presence can be readily distinguished through a microscopic examination.

A photograph was shown indicating the presence of a considerable quantity of the copper-copper suboxide eutectic in over-poled copper where such copper contained a comparatively large percentage of sulphur. The picture exhibited was that of an over-poled specimen carrying 0.012 per cent. sulphur.

A number of pictures were exhibited showing the relation between the set and microstructure of wire bar copper. Also, the influence of the amount of oxygen present upon the soundness of the bars.

Photomicrographs of native copper samples from Lake Superior were shown. These have the same type of structure as wrought copper. The crystals, however, are very much enlarged probably due to the very slow formation. The pressure exerted upon this copper in the rock produces the same form of slip bands as those shown in the crystals of cold rolled copper. A number of photomicrographs were shown indicating the various types of structures of hot rolled, cold rolled, drawn, and annealed specimens. Attention was called to the oxygen spots in this material and their absence in wrought specimens of copper which had been deoxidized at the time of casting. Several diagrams indicating the influence of cold working upon the physical and electrical properties of copper were discussed, and the influence of annealing at various temperatures on these properties, and, also, upon the microstructure noted.

The hope may be expressed here that Mr. Bassett's able paper will be published in full with the full series of microphotographs.

The Microscope in Mineralogical Analysis

A paper on this subject was presented by Mr. **Gilbert Rigg,** research engineer of the New Jersey Zinc Company,

Mr. Rigg has probably been the first to apply color photography to metallography. He exhibited a striking series of Lumiere plates showing photomicrographs of zinc ores, with resolution of the minerals present. This beautiful set of colored photomicrographs fittingly closed the official program.

In view of the late hour, no time was left for extended discussion. But Professor William Campbell also showed some interesting slides of photomicrographs.

Microscope Exhibit.

A very interesting exhibit of microscopes of the firm of Ernst Leitz, New York, was inspected by many of those present and explained by Mr. A. Traeger after the close of the meeting. As this exhibit showed the remarkable advances made in recent years in the design of microscopes especially for metallographic work, some brief notes on the principal types exhibited should be interesting.

The Leitz micro-metallograph is constructed after the le Chatelier principle and embodies some suggestions of Prof. Guertler, of the Technische Hochschule in Charlottenburg, and Dr. Wm. Campbell, of Columbia University. It is being used by the leading metal industries in their laboratories distributed over various departments. The special advantage of the Leitz micrometallograph is its extremely easy manipulation, the image, once observed by the eye, can be immediately transferred to the ground glass or plate respectively, after the ocular tube has been removed out of the optical axis. The instrument itself is mounted on a heavy triangular optical bench, thus eliminating any vibration which is most essential, considering the fact that practically in every industrial laboratory, vibration to a certan extent is experienced, this due to the factory being at a close range of same.

This instrument was shown with three different optical outfits. First, the achromatic, or ordinary microscope objectives, are used mostly for routine investigations and especially in cases where the instrument is not desired for the photo-micrographic study of metals, opaque ores or alloys.

Second, the semi-apochromatic objective series is advanced in its constructions over the achromatic objectives, this due to the increase of flatness of field, color correction and resolving power. This series of lenses is recommended, in preference to the achromats, for the visual observation and photo-micrographic study.

Third, the apochromatic objectives, however, represent a series of lenses of highest efficiency. The color correction, resolving power and flatness of field, have been increased to the highest state that optical science provides for at present. The apochromats come especially recommended for the photo-micrography of metals, alloys and opaque ores, and the results with these lenses are superior to those which may be obtained with either one of the optical equipments mentioned above.

Another interesting instrument exhibited was a small metallurgical microscope (Leitz Model B), constructed after the suggestions of Prof. Wm. Campbell. This metallurgical microscope is of a smaller type and recommended for use in those laboratories where the metallographic study is only attended to when occasion arises. This instrument, combined with a small upright photo-micrographic camera, serves advantageously for the photo-micrographic study of metals, alloys and opaque ores. A decided advantage of this apparatus is its detachable model. While small metal pieces are placed on the stage of the microscope (the latter is supplied with rack and pinion movement for cross focus) this method of investigation would not be possible for large metal pieces. In this instance, the upper part with microscope tube is removed, the microscope table, mounted on column, eliminated and the upper part attached direct to the horseshoe base. The microscope stand, if assembled in this way, can be placed direct on large metal surfaces.

The Leitz-Greenough binocular microscope, which was also shown, is supplied with a prism arrangement, allowing the use of both eyes for the stereoscopic vision of cross minerals, metal pieces, etc. The stereoscopic image is erected, this contrary to the results obtained with the regular compound microscope.

Another interesting exhibit was the Leitz petrographic microscope, constructed after the suggestions of Prof. Chas. Berkey, of Columbia University, especially for work in laboratories of industrial concerns and educational institutions. The optical equipment which is used in connection with this instrument covers an essential outfit needed for the routine observation of minerals, etc.

The exhibit also included a special microscope stand for the advanced study of mineralogy, and another microscope stand specially designed for chemical laboratories where frequently the observation of specimens under polarized light and then again the regular biological observation is necessary. The polarizing adjuncts, therefore, are mounted in such a way that they are easily removed in order to render the microscope available for biological observation.

The next meeting of the New York section of the American Electrochemical Society will be held jointly with the New York section of the American Institute of Mining Engineers on Thursday, November 20, at the Engineering Societies Building, 29 West Thirty-ninth Street, New York City. The subject will be the Metallurgy of Zinc, and figures will be presented by Messrs. G. C. Stone, W. R. Ingalls, and Victor Engelhardt.

Calculating Sulphuric Acid in Vats.—The following tables, given by W. Shellshear in the *Mining and Engineering Review*, Australia, facilitate the calculation of the quantity of acid in a vat. The vat is first measured and its water content obtained and tabulated per inch of depth. From this the amount of acid in the vat is read as tons of water. This reading can be converted into tons of mono-acid by multiplying by the sp. gr. of the acid, and by the percentage strength of acid corresponding to this sp. gr. That is: Tons of mono-acid = tons of water X (sp. gr. of acid × per cent strength of acid), or tons of mono-acid = tons of water X. The value of X can be calculated for different specific gravities.

Thus, if the sp. gr. of acid is taken by the 1 waddell hydrometer at 15° C., the table would be:

Tw.	X	Tw.	X	Tw.	X	Tw.	X	Tw.	X	Tw.	X
80	.703	92	.819	104	.936	116	1.054	128	1.181	140	1.312
81	.712	93	.829	105	.946	117	1.064	129	1.191	141	1.323
82	.722	94	.839	106	.956	118	1.075	130	1.201	142	1.334
83	.731	95	.848	107	.967	119	1.085	131	1.212	143	1.346
84	.741	96	.858	108	.977	120	1.096	132	1.224	144	1.357
85	.751	97	.869	109	.987	121	1.107	133	1.233	145	1.369
86	.761	98	.879	110	.996	122	1.118	134	1.244	146	1.380
87	.770	99	.889	111	1.006	123	1.125	135	1.256	147	1.392
88	.780	100	.895	112	1.015	124	1.139	136	1.267	148	1.403
89	.791	101	.905	113	1.025	125	1.150	137	1.278	149	1.415
90	.800	102	.916	114	1.035	126	1.160	138	1.289	150	1.427
91	.810	103	.926	115	1.044	127	1.170	139	1.301	...	.....

Example: A vat holds 18 in. sulphuric acid of 105° Tw. The vat when full to the same depth of water holds 5 tons. Then the mono-acid in the vat = 5 X, or 5 .946 = 4.73 tons.

The Brush Discharge
By A. Vosmaer, Ph.D.

The literature on the brush discharge is very scarce. Most scientists work on too small a scale, while practical men have neither the time nor the opportunity to study the brush discharge as such.

For this reason I hope that the following account of my personal experience of fifteen years with brush discharge phenomena will be found useful.

Part I.—The Brush Discharge through Air without the Use of Solid Dielectrics

There is perhaps no essential difference between the passage of electricity in a solid, a liquid or a gas, although it is customary to call the first conduction, the second electrolytic (ionic) conduction and the third convection. It would perhaps be better to consider all of them to be convective in character.

In any case a potential difference between the two points considered is essential for a current; if there is no P. D. there will be no current. It is immaterial whether we think of P. D. as the first cause or whether we look upon resistance as the essential for a P. D. again.

In the whole of physics the rule holds that there can be no force exerted unless there is a resistance against which said force can be applied. Sometimes action creates its own reaction (static back pressure). There is a general tendency in nature to reduce all "free energy" to a minimum, thereby increasing the entropy to a maximum; all water at a high level will run downward; all differences in temperature will be equalized at the cost of the higher temperature; never will any amount of heat as measured by heat units be capable of raising the temperature of something that has a higher temperature. In one word, in nature's free state all energy change is in the direction toward decrease of intensity and increase of capacity.

Now if said change is not checked in some way or another it will exhibit itself; the usual way of checking is by means of the unknown entity called resistance.

Ohm's famous law is usually expressed by saying that the current is the quotient of tension and resistance, but it would be more logical to say that tension is the product of current into resistance. The first way, however, is much more convenient when reasoning in a popular way upon some common thing.

A potential difference, however small, even when infinitesimal, will always cause a current of electricity to flow through a solid conductor (if we may use the term of flow). But this is not true for an electrolytic conductor, in which case the impressed e.m.f. has to be greater than the counter e.m.f. of polarization in order to produce a current.

In gases the problem is still much more complicated as we shall learn.

We may neglect the counter e.m.f., but there is a lower limit of e.m.f. below which no current will pass through a gas. The value of this lower limit of e.m.f. varies with such factors as the temperature, the degree of ionization, the shape and state of electrodes, etc. Therefore, the value of this lower limit is not a constant at all and cannot be given even approximately. It may be in the neighborhood of a hundred volts, or much higher.

The discharge of electricity in a gaseous medium depends on quite a number of factors, such as the pressure of the gas, its temperature, its nature. Further, it depends on the shape, on the size and spacing of the electrodes, and on the finish of each of them. Moreover, there are some secondary influences such as radiation (ultraviolet light) and the effects of a magnetic field or an electric field. It also depends on the kind of current supply, its tension, frequency, wave form and the circuit as a whole.

We shall discuss these influences in succession. Evidently the problem is rather a complicated one so that we shall leave out of consideration many important details.

PRESSURE

In the first place we shall have to confine ourselves to the study of the discharge in a space filled with gas and will not consider the phenomena in vacua, as these would form a treatise many times the length of this one.

It may be mentioned that a pressure lower than the atmospheric, greatly facilitates the passage of a current down to a certain point where there is so little gas left that there are not enough ions to convey the electricity.

The brush discharge is affected in such a way that even a small diminution of pressure changes its character altogether. In view of this fact, one may feel inclined to try higher pressures. But the same holds true there, though in a less degree. We have tried up to three atmospheres, but every increase in pressure seemed to make it more difficult for the brush to keep up its being.

Watson, when constructing his high-tension voltmeter, has taken advantage of the fact that at high pressures gases become insulators. They are very poor conductors when liquefied; the conductivity of liquefied gases is of the same order as that of pure water.

TEMPERATURE

I have had no occasion to experiment either with very high or with very low temperatures, but it is probable that the first will be detrimental to a true brush discharge and the second will not have much effect until extreme temperatures are reached.

MOISTURE

It is several years ago that Steinmetz, experimenting on high-tension sparks, published the result that moisture has little effect on the dielectric strength of air, and what influence it has points to increase rather than decrease as one would suspect at first thought. The brush discharge does not seem to be sensitive to moisture; although there is some evidence pointing in the direction of decrease of P. D. for the same brush, I would not dare to claim this as a fact.

KIND OF GAS

Since the object of my researches has been the manufacture of ozone, I have always been experimenting with air or oxygen and have not tried other gases except hydrogen and carbonic acid. No marked change in the character of the brush could be detected when going but superficially into this matter. It would have been very interesting to know just what happens when other gases are subjected to the very strong influence of the brush discharge, but the scope of my work was already too big so that I could not go too far beyond it.

IONIZATION

It is a very strange fact that though the brush discharge is powerful it does not seem to have much force of ionization. When a discharge of as much as 100 watts was confined in a small tube of glass and the air blown to a charged electroscope, after having been filtered through cottonwool, it did not change the position of the gold leaves, no matter whether they were negatively or positively charged.

This result surprised and annoyed me because I had expected to be able to prove that the brush discharge is essentially a positive one. I have every evidence that it is a discharge from the positive wave and not from the negative, but there are many investigators who hold the reverse to be true.

KINDS OF DISCHARGES

Before proceeding I wish to call particular attention to the fact that for the present moment we are considering discharges in free air, no solid dielectric being between the electrodes; the latter case will be considered afterward.

In free air, then, at atmospheric pressure and normal temperature, there are four distinctly different kinds of discharges, viz., the glow, the brush, the spark and the arc.

The *glow* is the first stage. It is merely a bright spot on the electrode and causes[1] no appreciable loss of energy unless very prominent, in which case it is very liable to become a brush.

[1]The corona loss, which is caused by the glow discharge, is but small compared to what it would be were it a brush discharge.

The interest in the glow discharge has greatly increased since in high-tension power transmissions the voltage has been varied so much as to bring about the corona effect.

There is much information now to be had on this subject of the corona effect which a few years back had no interest for the practical men. The corona loss starts at the point
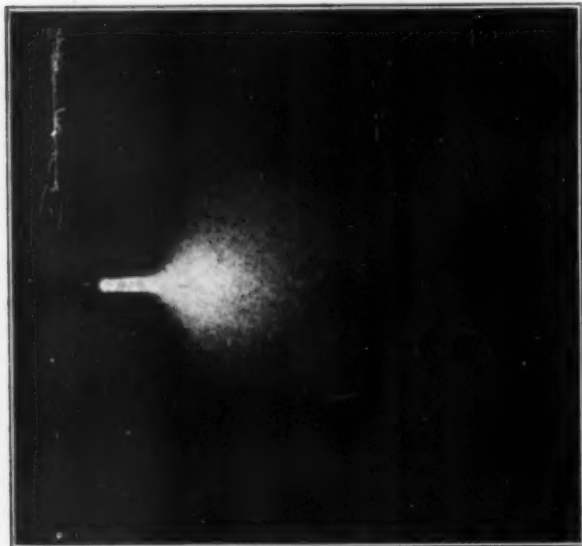
FIG. 1.—BRUSH DISCHARGE

when the glow is about changing to the brush. There is no sharp line of demarkation between the glow and the brush discharges, though in their most characteristic forms they show no resemblance to each other.

The true *brush* (a photograph of which is reproduced in Fig. 1) has very distinct features. Its color is a dark bluish
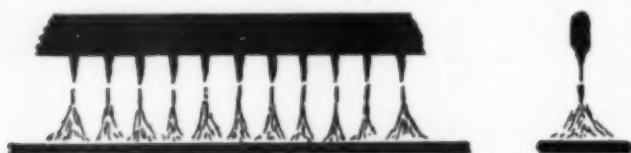
FIG. 2.—BRUSH DISCHARGE

violet, its hissing sound and "wind" are well known,[2] its shape is a straight stem detached from the electrode from which it starts or rather separated from it by a dark space, and at its end there is a widely spread out cone. This cone or conical
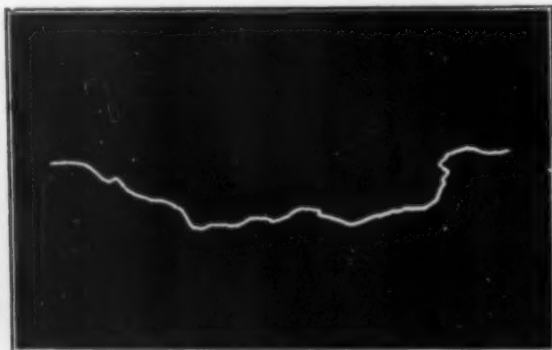
FIG. 3.—SPARK

end may be flattened into a fan-shaped end, but not in all directions.

It is very important to remember this special form of the brush, as it gives a clue to many phenomena which are apt to appear when one is building up an ozone apparatus.

The ignorance of this particular behavior of the brush ac-

[2]The names, Silent Discharge and Dark Discharge should be dropped.

counts for many a failure in actual practice of ozonators, as we shall presently see.

The brush is a three-dimensional discharge; at the best it may be reduced apparently to two dimensions, that is, it may be flattened in one direction so that it looks as though it had no thickness. Still one should never lose sight of the fact that it has to have some extension in space in all directions.

For practical purposes this means that one cannot possibly have a continuous line of discharge. There must be free
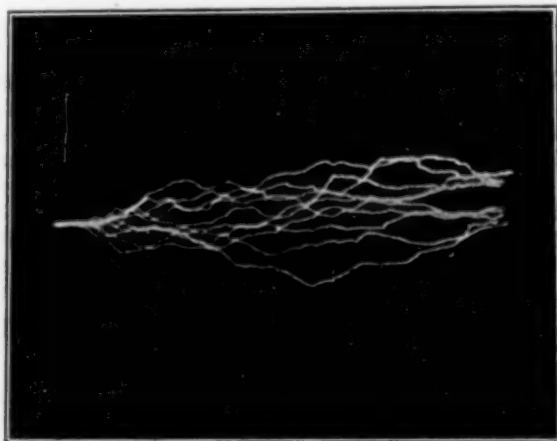
FIG. 3A.—SERIES OF TEN CONSECUTIVE SPARKS

space left between the different discharges, or in other words, it is necessary not to use a perfect smooth line, like a razor blade, but a dented one, for the discharger.

Fig. 2 explains this sufficiently. The latter has been exaggerated purposely. In actual praxis, using 1.3 millions of points for a 20-kilowatt apparatus, there were 36 points used per inch. Sharper and longer points allow to use 50 points per inch.

All this refers only to spacing in one direction. We shall see later on what the spacing has to be in the other direction, that one being more evident on account of the visible spread out at the base.

The brush discharge passes over again into the *spark* without a sharp boundary between them, although here again the brush and the spark, in their most characteristic forms, do not have any resemblance.

The spark is characterized by its white yellow color, its peculiar zig-zag path, which under certain circumstances can
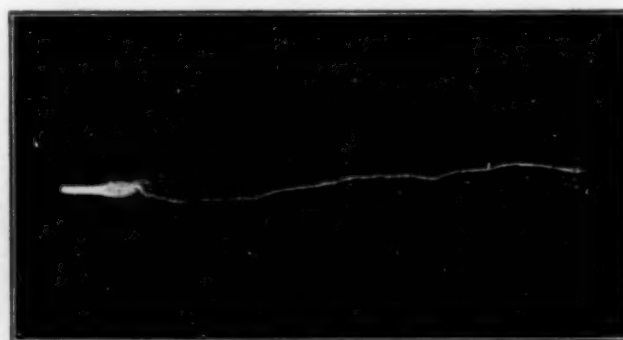
FIG. 4.—SPARK MIXED WITH BRUSH DISCHARGE

be made straight, its loud report and its oscillatory motion, in contrast to the brush which is unidirectional and not intermittent.

Fig. 3 shows a photograph of a spark of 10 in. in length given off by a powerful 12-plate Whimshurst machine. Fig. 4 shows the mixing of a spark and some faint brush discharge from the same machine, run without its condensers. Fig. 3a represents a series of ten consecutive sparks.

If circumstances are such as to allow of it, a spark will

change to an *arc*. This is most dangerous of all forms of discharges on account of the tremendous amount of energy transformed into heat and concentrated in a small space; it generally means ruin of the apparatus unless checked in due time or taken care of and controlled by some method such as those now used in the systems of making nitrous compounds out of the air.

We shall not discuss in detail all these discharges, but had to mention them because we shall have to refer to them.

FIG. 5.—ARC

The arc (Fig. 5) is very hard to photograph because it is so restlessly moving about. Its characteristic features are its faint blue color, its intense heat and its continuity.

POLARITY

When we speak of the brush we always mean the positive brush because there is no real negative brush, although there is a negative discharge under the same circumstances.

In Fig. 5a we show side to side the positive and the negative discharge. The difference in appearance is striking, but could have been shown even much more strikingly had I taken other prints.

If matters are arranged in such a way that the pointed discharger is made the negative pole, all we obtain instead of the beautiful brush is a tiny little violet spot about one-tenth the size of the positive brush or sometimes even less than that. The demonstration of this very marked difference is quite easily made. It used to strike most scientists who watched it. A powerful Rhumkorff induction coil is the best source of supply for this experiment, as it gives practically unidirectional high-tension current, the intermissions are too short to be noticed, and if the output is taken up by a good number of points, say several thousand, then there is no interference from undesired sparking.

FIG. 5A.—POSITIVE BRUSH (LEFT) AND NEGATIVE DISCHARGE (RIGHT)

It is known that a Rhumkorff gives a secondary current of very peculiar wave form, but that is no objection.

ELECTRODES

Shape and Size of Electrodes.—There are many variations to be tried. First let us take two flat surfaces, the discharge invariably will take place at the edge because here the situation differs from that at other points, the electric charge being greatest at the edge. In the center of said flat surfaces there can be no discharge whatever, while from the edges an irregu-

lar and rather poorly developed brush may occasionally start.

The next experiment is to take two spheres. There can be no brush discharge under ordinary circumstances of operation. If the spheres are of equal size, the equipotential surfaces have the form of spherical shells or rather ellipsoidal shells, quite unfit for our purpose.

Two parallel wires are unsuitable for the purpose of the brush discharge for the same reason, namely, the fact that the equipotential surfaces are coaxial with the wires.

Two crossing wires may give rise to a brush, but will not do so unless very carefully arranged. As a rule a wire is a very bad shape for a brush and this is fortunate, since this is the reason why after all the corona loss does not amount to very much even on very high tension.

Two points cannot give off a brush discharge, unless under very special circumstances; it is very difficult to obtain a brush and it is impossible to work with it. All these facts are easily told, yet, until we understand the exact conditions of the true brush, they seem puzzling.

If we refer to Fig. 1 it is easily understood that the arrangements of electrodes just summed up cannot give a brush discharge. Since the origin and end of the discharge are different, the two electrodes should also be made different; that is, we must not take two electrodes of *equal* but of *different* shape.

Let us now consider these cases and also take into consideration another circumstance, viz., that of sign or polarity.

A great many combinations could be considered, but as none of them except one will answer our purpose we can be very brief about the others. It is of no use summing up all of the combinations; just a few may be enough to bring out the evidence clearly.
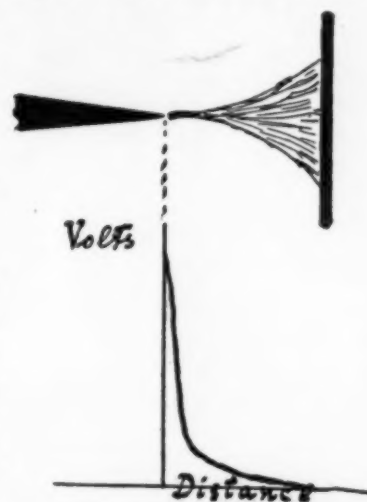
FIG. 6.—BRUSH DISCHARGE AND POTENTIAL GRADIENT

A positive plate and a negative sphere give no brush.
A positive plate and a negative wire give no brush.
A positive plate and a negative point give no brush.
A negative plate and a positive sphere give a brush.
A negative plate and a positive wire give a brush.
A negative plate and a positive point give a beautiful brush.

(The reader will permit us for the sake of brevity not to dwell upon the fact that, of course, such terms as sphere and point require a more precise definition, but as the boundaries of discharges are just as vague as those of shapes, which after all differ only in degree of curvature, there is no need of further definitions and we trust on the reader's good will for understanding.)

So much on the question of shape. Evidently there is no choice left. The best arrangement is to have the discharge from a pointed toward a flat surface, and if we make a drawing of the potential gradient that is likely to occur it will be clearly like the curve shown in Fig. 6.

It might be said here that the photograph of the true brush in Fig. 1 has been taken from one in free air from a small sphere against free air, no opposite pole being provided so as not to influence beforehand the free development of the brush.

In actual work one uses alternating current because direct current of very high tension (say 10,000 volts) is not so easily available as is alternating current. As it is only in the half-period in which the point is positive that it discharges a

brush, the negative half-period is lost, not with respect to energy, but with respect to time.

There is a simple way to make up for this, shown in Fig. 7. Here each discharger proper is intended to emit the electric discharge from its sharp edged side when positive and to receive it on its flat back when negative (if we may express ourselves in a popular way). There evidently is no gain at
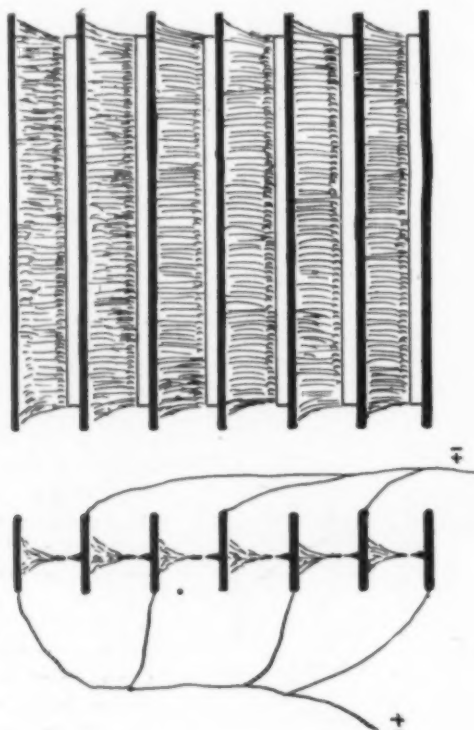
FIG. 7.—ARRANGEMENT OF DISCHARGE

all except in the reduction of the size of apparatus for a given capacity.

The sharper the point the better it is; that means the less voltage it takes to have a discharge. In actual practice I used at first steel needles made especially to suit the purpose. But when I had to increase the capacity of the apparatus from two to twenty kilowatts it could not be done in that way on account of the high cost, as there were 100,000 needles per kilowatt. For this size of ozonator I used No. 35 pure nickel strips toothed like a saw (36 teeth per inch) and for the other electrode a nickel strip of suitable width, the width depending on the polar distance. In my case the width was $\frac{3}{4}$ in., the polar distance being $\frac{1}{2}$ in.

The size of the dischargers proper is of much greater influence than one might imagine at first thought. The flat surface should be $\frac{1}{4}$ more than the polar distance.

The size of the positive sharp electrode matters little, but
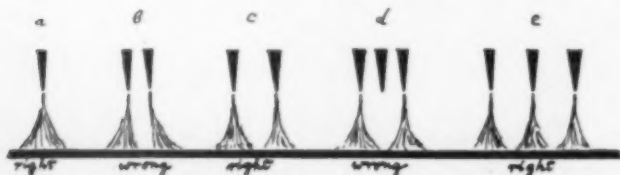
FIG. 8.—SPACING OF DISCHARGES

it should not be extremely short as it should be free from the influence of the electric field caused by its back.

There is a very convenient check to find out whether or not an ozonator has been designed properly. If it is properly designed the energy it takes is directly proportional to the total length of dischargers (or number of points).

This statement will seem self-evident. However, those who have been working in this field know that at the beginning

when the experimenter does not yet know all these details he is every now and then surprised and very often puzzled as to the reason why after an apparatus has been built for say 100 watts, on making it twice as large it does not take twice as much energy.

That will happen when the rules governing the brush discharge are overlooked, due to ignorance. I may say here that it has taken me over 12 years of experimental work and practice to bring the whole affair to a satisfactory end.

We will now describe an instance in which multiplication of discharging points does not correspond to an equal multiplication of wattage.

Spacing of Electrodes.—The spacing apart of the different parallel dischargers proper is an interesting point of great importance. It bears on the principle of electrical shadow.

An example will make clear what I mean.

In Fig. 8 *a, b, c, d, e* are the dischargers proper, mounted in such a way as to allow of easy displacement sideways when under test.

One strip (*a*) will give a perfect series of brush discharges when connected up to the source of electricity, a 10,000-volt transformer.

Now move a second strip near to its side. At a distance from the first strip of say anything above an inch it will work just as good as the first. The energy will be twice what it was before (case *c*).

But when the second strip is moved nearer and nearer to the first one, the discharge is losing in brightness (*b*). Now let us move it away again till all is as bright as possible (*c*). Suppose this occurs at a distance of $\frac{1}{4}$ in.

Put in a third strip, make the distance again $\frac{1}{4}$ in. Then the second discharger will be extinguished and only Nos. 1 and 3 will work (case *d*).

Repeat this with a fourth discharger and so on and it will be seen that any but those at the end are extinguished. The inside dischargers will not discharge at all.

The energy consumed is therefore not proportional to the number of strips, unless these are spaced apart so far that they do not longer interfere with each other's action (case *e*), that is until they are beyond each other's shadow.

Since this spacing depends on the polar distance, at greater polar distance the brush spreads out wider and requires more spacing.

This experiment, which is very fascinating to watch, explains why multiplication of dischargers not necessarily means equivalent increase in capacity. It also makes clear the reason why from a flat surface one does not obtain any discharge from the central part, but only from the edges.

I may once more draw attention to the fact that we are speaking of discharges in free air without any solid dielectric being placed between the electrodes. If this is done, as we shall see later on, the conditions of working are altogether altered.

(3) *Material and Finish of Electrodes.*—It is quite immaterial of what material the electrodes are made. I tried nearly all the more easily available metals and never found the slightest difference.

For the purpose of ozone making platinum would be the best, or gold, but, of course, these are out of question on account of excessive cost. Silver is rapidly corroded by ozone, and so are aluminium, brass, zinc, iron, but copper stands well and so does nickel.

But besides resistance to corrosion there is another property to be considered, viz., that of hardness. It is a very curious phenomenon that the perpetual bombardment of the negative electrode should result in an actual wear. After a year's use the flat nickel strip shows flaws, it has the appearance of a skidded rail (in miniature). But one would not expect wear on such a hard metal as nickel by bombardment of air molecules.

There is no wear whatever on the positive strip so evidently the wear is not through metallic particles of the positive strip. This is important to note for a wear of the positive electrode

would indicate a change in the condition of working. Fortunately this does not happen.

The discharging positive electrode should be sharp-pointed, not sharp-edged. A razor blade gives very poor brushes. There must be real points because the brush must have a support for its stem. Perhaps it is better to say that the stem of the brush must have an inducement to build itself up, this inducement being provided by discontinuities in the line made either like teeth of a saw or as true points (needles).

The finish of the negative electrode should be smooth, without protruding parts or sharp edges or corners. These ought to be rounded off.

ELECTRIC AND MAGNETIC FIELD

The influence of an electric field is very much disturbing and in large apparatus it may be very difficult to avoid it.

We have already spoken of the disturbance caused by the own electric shadow of the discharges, but here we have in view the stray fields caused by the metallic parts of the apparatus.

We have experienced great trouble from this cause and the most convenient way to avoid it was to have part of the apparatus built of wood instead of metal. These stray fields are uncontrollable and cannot be neutralized by proper grounding. By the way, it may be mentioned here that grounding a high-tension circuit is not such an easy thing as it looks.

A magnetic field affects the brush discharge just as it would affect an ordinary alternating current. A strong field tends to "blow it out" and a tendency of sparking is set up.

As to the influence of electric radiation, such as ultraviolet light, this question has not yet been settled. Some people claim a very decided influence of ultraviolet light radiation on the working of brush discharges. I have never been able to detect any at all, but this may have been due to the powerful discharges which I used.

CURRENT SUPPLY

(1) *Source of Current Supply.*—For the study of the discharge, a statical machine is a very convenient source for the current but that is all. Any practical use is out of question for well known reasons.

The use of Rhumkorff induction apparatus is the next step for an experimenter. The wattage that can be obtained is much higher than that from the former machine, but it is still of no practical use. Full credit may be given to the very interesting experiments one is able to make with it, but it can only be employed for research, not for actual use.

A high-tension direct-current machine, or direct-current on the Thury system has for a long time been my desideratum, but so far I have not been in a position to experiment with this kind of current.

Alternating current has been my regular source of supply, the generator giving 110 volts, the transformer up to 60,000 volts for experimental work. Under practical working circumstances I have used 10,000 volts. (I may call attention here to the fact that at the time when I started my experiments, viz., in the year 1898, such high tensions were an absolute exception in my country, Holland, and the only possibility of using 60,000 volts was to build the transformer myself.)

(2) *Tension of Current Supply.*—It goes without saying that there is an intimate connection between the width of the air gap and the tension of the current. It is easy to understand that the general formula will be $V = a + bl$ which means that in general the potential difference required to send the discharge through the air gap will be made up of a constant factor a and one depending on the width l of the gap.

One may thus adapt either the polar distance of the dischargers according to the tension of the current, or one may regulate the voltage according to the given distance.

When it comes to ozone making, however, and highest efficiency is sought after, there is no longer any such liberty in choice.

Down to a certain limit, the best yield per kilowatt-hour, as well as the highest concentration (two quantities that are in opposition to each other), are obtained with the smallest possible air gap, called polar distance. This point has to be considered very carefully.

For the true brush discharge there is a lower permissible limit of polar distance. Under the most favorable conditions this lower limit is about ¼ in. for safe working, however, it is hardly possible to go below ⅜ in., and as a rule we have worked our machines at ½ in.

This settles the question of tension, which may be about 10,000 volts (a.c.). Of course, it should be as high as possible in order to get the highest current density and thereby maximum of wattage, the limit being set by the production of sparks between the dischargers instead of the regular brush.
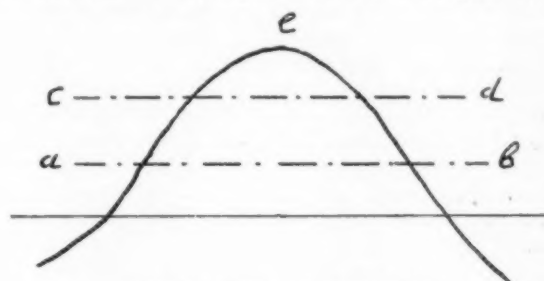
FIG. 9.—EFFECT OF WAVE FORM

(3) *Frequency of Current.*—The danger of sparking can be very materially diminished by raising the frequency of the current to an extra high value. We have tried frequencies up to 600 periods per second instead of the usual 50 (100 in my country in 1898).

The advantage of the possibility of using a higher frequency is counteracted by the fact that the output per kilowatt-hour is thereby reduced. When taking resource to high-frequency Tesla currents, there is hardly a possibility of the occurrence of sparks, but we have the drawback of an enormous decrease in output.

These facts indicate advantages in the use of direct current for ozone making purposes. Perhaps somebody will take this up in future.

(4) *Wave Form.*—The wave form of the electromotive force is of theoretical, rather than practical importance.

Still when we consider the question of wave form, it becomes clear why we can have a brush discharge without dielectrics.

Referring to Fig. 9, let the line *a b* represent the minimum voltage at which a discharge will occur. Then, if the top *e* represents the voltage at which sparking will take place, it is quite clear that if we know of a way to keep the actual voltage between the dischargers below that point *e*, say at the line *c d*, there will be no sparking, since the voltage is not high enough for the spark discharge, the polar distance being given.
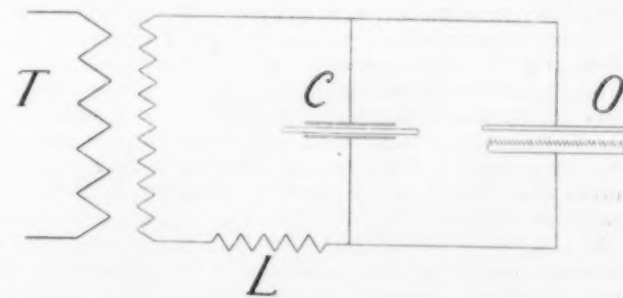
FIG. 10.—CONNECTIONS

That is what is actually being done when we arrange a discharge to take place from sharp-pointed electrodes.

A spark discharge presupposes a certain amount of electrical charge. For just this reason it is not continuous but an intermittent, oscillatory discharge. The brush, however, is a steady flow and for this reason it does not give the electric charge an opportunity to accumulate for a spark; from a sharp point the electricity flows off so easily that there is no chance for a spark.

From this inference it should follow that a peaked curve would give more security against sparking than a flat one. In actual practice the deviation from the true sine wave is not so large as to make any difference for the brush discharge.

(5) *Safety Devices in the Current Supply.*—The discharge from either one point against a flat surface, or from a series of points of any desired length against a flat strip, all of suitable and harmonic design, can be a true brush discharge and will remain so for any length of time, *unless* there comes some disturbance, either caused by a raise of tension, or by a particle of dust or oxide that may cause a spark to be formed.

Now a spark means a lowering of resistance, of course, at once followed by an increase in current density at that spot. This means raise of temperature, causing again a decrease of resistance, etc. Evidently when a spark is once started it will not only remain but will increase.

When we deal with an ozone apparatus of many hundred thousands of points, it would not be possible to avoid all and every disturbance that might happen to come. But as it is of great advantage to have the apparatus work without any attendance at all, some safety device has to be applied and this is what we will now briefly discuss.

Fig. 10 shows a special way of making the connections (patented by me in 1902); in the circuit from the secondary terminals of transformer T there is a self-induction L in series and a capacity C in shunt with the wires that lead to the ozonator O which represents a certain resistance.

Through the combined effect of self-induction and capacity the secondary tension will be raised (Ferranti effect) to such an extent that, while the ratio of transformation of the transformer is 70, so that under ordinary circumstances the secondary tension would be 7700, yet in this case it rises to 10,000, but not so unless there is a *certain* resistance at O.

Suppose this resistance drops off, say, on account of a spark, then the rise just mentioned from 7700 to 10,000 volts will not take place. The voltage will be less. As soon as this is the case, the cause for the spark has also ceased or the possibility for its maintenance has vanished, the result being that any spark just about to start or already started, will, by its own being, make its continuity impossible. It checks its own existence and it does this in a most beautiful and startling way with surprising accuracy.

The raise of tension is the greater the more the product $L C$ approaches unity. It can never be greater than under this condition.

From a theoretical standpoint it is immaterial whether we obtain the raise of voltage through increase of L or increase of C, but when the load is heavy, *i.e.*, the resistance is small, then one should rather increase C as an increase of L causes too much phase lag.

From the foregoing it will be understood that in the design of a large-sized ozonator every item has to be carefully calculated and the whole system has to be in perfect harmony. If this is so there is no trouble, no attendance is required. When the apparatus has once been adjusted to the point of best working the occasional sparks are taken care of by themselves (some little sparking does not interfere with the proper working and is hardly to be avoided on account of particles of rust on the electrodes).

The principal advantage lies in the fact that with this arrangement the arc discharge is an *absolute impossibility* (even when the tension is raised 20 per cent purposely, to demonstrate this fact).

It should be borne in mind that in this arrangement there is no spark gap, as in the Tesla method, which would cause high-frequency discharge.

Perfect and most strikingly beautiful brush discharges can be obtained in this way, and in an absolutely reliable working condition.

As explained, this way of making the connections has to be considered as a safety device. The discharge itself is not altered at all. It may be just as good when the usual connections are employed. This brings us to the second part.

Part II.—The Brush Discharge with the Use of a Solid Dielectric

As a result of the desire of having some safeguard against the dangerous arc discharge, several devices have been invented and applied. Since the days of the first laboratory ozonator the principle of placing a solid dielectric between the electrodes has been applied by numberless "patentees." We shall deal with this at greater length and, therefore, will first mention other systems.

The drawback of the use of glass is its liability to crack and that is why many have endeavored to do without it

It was in 1894 that Schneller announced that he was able to obtain the brush discharge without making use of any solid dielectric. This was at first considered to be an impossibility, but Schneller proved the soundness of his assertion by constructing a 2-kw apparatus which did the work, to everybody's surprise.

Schneller inserted a "high resistance" in the high-tension circuit, said resistance to be of the order of 20,000,000 ohms and made of a glass tube filled with 80 per glycerine. The principle, though interpreted in an altogether wrong way, had the merit of being quite new and Schneller's experiments were pioneer work.

For his 2-kw apparatus he used seventy-five of these glycerine-filled tubes of 20,000,000 ohms each, in parallel with his 50,000-volt circuit. The discharge he obtained was a beautiful sight but viewed from the commercial standpoint the system proved to be a failure because of its extremely low efficiency.

From the scientific standpoint it is interesting to point out that said "resistance tubes" do not work as ohmic resistance, but as a pseudo capacity. It has taken me quite some time to find that out, but it is beyond question.

It is easy to demonstrate that an ohmic resistance does not do the work but, on the contrary, provokes arcing instead of preventing it. This fact is quite in accordance to the theory of the discharge.

A few years later Schneller took out a patent for the use of enamel as dielectric, but had the shrewdness not to call it such. He said it was used for having a more equal and smooth surface of electrode!

The next thing that came out was the use of high frequency for the purpose of ozone making. Now it happens to be so that the unsurpassed beauty of the Tesla dark discharges has no bearing on their efficiency and that killed the system.

It is true that with this system there is no danger at all from arcing but as after all the object is ozone manufacture rather than display of beauty the system has never entered the market.

Another device was that of Otto, who tried the use of revolving electrodes in order to either prevent arcing or when arcs were formed to extinguish them by drawing them out.

The system never did any good because arcing should not be *corrected* but *prevented*. Arcing causes nitrous compounds to be formed and causes great damage to the apparatus.

After having been experimenting with all known systems and after studying them carefully, I came to the conclusion that in order to obtain the brush discharge and nothing but this particular one, it is not necessary either to use solid dielectrics between electrodes, or a high resistance in series, or a high-frequency current, or revolving electrodes. All that is really necessary is a thorough knowledge of the subject and according to that, we should endeavor to realize in actual practice what theory indicates as advisable.

This has led me to my system and the fact that I admit frankly that my system has not any more raison d'être on account of its low efficiency will make it clear to the reader that it is not as a rival or competitor that I now classify all systems as dead ones, except one which is based on the use of a solid dielectric.

The reason why I have been dwelling so long on those others is just to point out the *importance* of the latter one and to prove that its survival is not a mere chance or commercial attainment but the logical outcome of merit.

In order to fully appreciate the glass-dielectric ozone ap-

paratus, it was necessary to learn by experience that it is the best we have at present and probably for the near future.

When using a solid dielectric there is no chance for a spark nor for an arc to set up. The discharge is always right, whatever the arrangement, and there is but one difficulty left, viz., that of failure of the glass.

Many failures on this account are due to overloading. Too much energy on a given surface causes too much heating up and this will always result in a breakdown, sooner or later, but usually sooner.

The perpetual heavy dielectric strain on the glass also causes occasionally or perhaps always, a change in the nature of the glass, which as is well known is very far from being a body in molecular equilibrium. Dielectric hysteresis is another source of heat and danger.

The success of a glass ozonator, evidently, depends therefore, for the greater part on the quality of the glass. This is a physical and a chemical problem rather than a technical one for the present.

The technical side of the glass ozonator is no problem at all for those who are familiar with the business. The failure of so many "systems" is the logical result of ignorance.

The second great advantage of glass-dielectric ozonators is that they allow of a very small polar distance of dischargers, and that means high concentration as well as high output if the current density is great, the difference in yield being up to ten times as much. This puts all the other systems out of service.

Thus it happened that after twelve years of elaborate experimental and practical research, I finally had to give up my system for a better one, the original glass dielectric system. But facts are facts and science takes no notice of personal pride and ambitions.

One advantage I have gained and that is impartiality, since now I have not a system of my own to bring to the front and to recommend and am at liberty to consider the matter from the impersonal scientific standpoint.

There are numberless patents for ozonators. It would fill up a book were we to consider or even mention them. Most of them are valueless, some of them are ingenious.

Some people prefer glass plates to glass cylinders, others do the reverse. Some believe in the beneficial effect of cooling the air, others do not. Some people think much of complicated arrangements, others believe more in simplicity.

There are, however, some details of interest, but as we intend to discuss ozonators on another occasion, we shall not refer to these here. If the dielectric system has so many advantages and but one disadvantage, namely the treacherous character of glass, why not use any of the many other solid dielectrics? That is a question likely to be put forward. It is because no other dielectric will do.

Ozone being such a powerful oxidizing agent, is detrimental to most dielectrics of organic base. Rubber, for instance, is destroyed in a few seconds. So none of that group can be used.

Moreover, the material in question has to possess certain mechanical properties and has to have a certain thickness. For this reason shellac or other varnishes cannot be used as they cannot be had in sufficient thickness.

The whole group of those conglomerates lack homogeneity and for that reason cannot be used. Others, again, like fibre, asbestos, paper, etc., are too porous for electricity, which "eats" its way through.

Then come some minerals. Most of them are not to be had in convenient shape. Slate is also porous. Mica will answer the purpose but poorly, as it cannot bear very well the heating up; its lamellation is a further disadvantage, the layers becoming more and more separated from one another until finally it is not one thickness but several. Micanite is no better.

Bakelite did not yet exist at the time when I tried every one of the dielectrics, so I do not know its behavior.

Of the fused materials there are enamel, porcelain, and vit-rified silica. The first can never be applied faultlessly on a surface, and even if it could it would be no good, its dielectric strength being too low and its thickness too small.

Porcelain fails through lack of homogeneity. So does, for the present, the vitrified silica; it is very fragile and its fusion has not been quite so complete as to remove all flaws, air bubbles, etc. It may be, however, that it will play an important rôle in ozonators in future because its quality is rapidly improving every year.

So it is that only glass combines all the requirements of dielectric strength, mechanical strength, chemical strength, and variety of shape and thickness.

One more point of scientific interest is the fact that the dielectric strength of ozone is much higher than that of air. If one leaves the ozone in the apparatus so as to get an increasing concentration the tension of the current has to be raised continuously in order to keep the wattage constant. This circumstance puts a limit to the maximum concentration of ozone obtainable; it may be in the neighborhood of 30 grams per cubic meter.

A fact, generally overlooked, is that a large load of ozonators brings a considerable amount of capacity into the circuit which should be checked by self-inductance.

The Metallurgy of Sudbury Copper-Nickel Ores

One of the two important commercial deposits of nickel-bearing ores in Canada is in the locality of Sudbury, Ontario; the other is in the Cobalt district in the same province. The treatment of the Sudbury ores is covered in some detail in a 200-page *Monograph* recently issued by the Department of Mines, Ottawa, Canada. The work is by Dr. A. P. Coleman, and is entitled The Nickel Industry.

The Sudbury ores include essentially only four ingredients: a magnetic sulphide of iron, which is practically free from nickel and copper; a sulphide of nickel and iron, which is non-magnetic; a sulphide containing equal parts of iron and copper, which is non-magnetic; and a variable amount of rock matter which may be of several different kinds, in the main non-magnetic, norite or the products of its weathering predominating.

Some of the ores are low in copper and high in iron, and an attempt has been made to convert these directly into ferro-nickel, but the experiment was a failure on account of the presence of too much copper. Magnetic concentration naturally suggests itself as a method of treating an ore which contains a magnetic mineral and several non-magnetic or feebly magnetic minerals, and a great deal of work has been done along this line, but without success. The reason for the failure is disclosed by an examination of photomicrographs, which show that the pentlandite (2 FeS. NiS) and chalcopyrite (Cu$_2$S. Fe$_2$S$_3$) ramify through the pyrrhotite (magnetic pyrite) in a very intricate manner.

At most of the mines a certain amount of hand-picking is done, in order to reject ore of too low-grade to be profitably treated, but no efforts have been made at concentrating this low-grade material. The mechanical separation of the sulphides from the rock can never be complete because of the intimate mixture of the two in the pyrrhotite-norite, into which the solider ore usually passes. In any event it is unlikely that much concentration will be attempted until the supply of high-grade ore becomes less abundant.

Metallurgical Processes

The usual metallurgy of the Sudbury ores includes four distinct processes: (1) roasting to remove part of the sulphur; (2) smelting in blast furnaces to produce standard matte; (3) resmelting the standard matte in converters to make a matte of 75 or 80 per cent nickel and copper; and (4) the separation and refining of the nickel and copper. The first three processes are carried on in the Sudbury district, and the methods employed do not differ essentially at the different plants. The refining operation is carried on in other countries (United

States, Wales and Norway) and is accomplished by a different process at each place. More or less secrecy surrounds the refining processes.

Heap-roasting is usually adopted for reducing the sulphur content of the ore to a point where it is suitable for smelting to standard matte. In preparation for a roast-heap, a layer of cordwood or dead pine is laid down to a deptht of a foot or 18 in., the space between the larger sticks being filled with smaller pieces to make a rather level surface. Small channels filled with kindling wood lead at intervals of 8 or 10 ft. toward the center of the pile, so as to light the whole heap uniformly. Coarse ore is dumped on this bed, making up about two-thirds of the whole. This is followed by medium sized ore, and the pile is then covered with fine ore. The whole pile will contain from 2000 to 3000 tons, arranged in rectangular form, with flat top and sloping sides.

The wood is fired and burns for about 60 hours, after which the sulphur in the ore continues to burn without further aid. From three to four months time is required to roast such a heap, and at the end of that time the sulphur content has been reduced to about 10 per cent and the iron is more or less completely oxidized. In the earlier stages of the roast a good deal of sulphur is sublimed from the interior of the heap and condenses in the upper part, but eventually this is burned away. Some leaching occurs when rains come on, and the colored water running from the heaps gives evidece of the loss of soluble metal. The roasted ore is usually well sintered, and may require the application of explosives to break up the larger masses.

Smelting at Copper Cliff

The metallurgical practice of the Canadian Copper Company, at Copper Cliff is described in the monograph by Mr. **D. H. Browne** as follows: When properly roasted the ore contains about 10 or 11 per cent sulphur, and is removed from the roast heaps by steam shovel and taken in 50-ton drop-bottom cars to the ore bins. The ore trains which supply the blast-furnaces consist of eight or nine side-dumping cars. The first three carry the coke charge, amounting to from 10 to 12 per cent of the weight of the charge; the next three carry the ore charge, which usually amounts to 9000 or 10,000 lb. of roasted ore; another car carries 2000 or 3000 lb. of Crean Hill ore, which does not require roasting as it contains only 12 to 14 per cent sulphur. Sometimes, if the ore is well roasted, 2000 to 3000 lb. of Creighton green ore can be added to the charge. Furnace scrap and quartz, when used, are carried in separate cars. The quantity of the latter varies from nothing to 2000 lb. per charge, according to the silica in the ore.

If the furnaces are choked by silicious ore or fine ore, lime may be used for a few charges instead of quartz. The coke is dumped in the furnace first, then the ore with its flux, then the scrap or floor screenings. The blast is normally 24,000 cu. ft. free air per furnace at about 25 to 35 oz. pressure. If the furnaces develop blow-holes due to choking from fine ore, the heat is thrown to the top of the furnace and crusts are formed. These may be cleaned out by charges of green ore and lime, which melt easily and carry the heat to the lower part of the furnace, undercutting the crusts, after which they can be easily removed by barring. There is no regular rule for running the blast furnaces, as the charge varies from day to day, and even hour to hour, with changes in the chemical or physical quality of the ore.

The five blast-furnaces smelt from 40,000 to 45,000 tons of ore per month, the amount of green ore varying with the condition of the roasted ore.

Green ore alone could be used in the blast-furnaces, but would produce a low-grade matte and throw an undue amount of work on the converter department, as shown by the following interesting comparison: To make 100 tons of Bessemer matte per day from a 10 per cent furnace matte would require fourteen basic-lined converters; from 15 per cent matte would require seven basic converters; from 20 per cent matte, five converters; from 25 per cent matte, four converters; and from 30 per cent matte, three converters.

Adoption of Basic-Lined Converters

Prior to March, 1911, the Canadian Copper Company had in operation ten stands of acid converters, with shells 84 in. by 126 in. lined with the usual quartz and clay mixture. Each shell consumed 3000 cu. ft. free air per minute at 9 to 11 lb. pressure. On a 36 per cent furnace matte, one lining lasted about eight hours and produced seven tons of finished bessemer matte, 80 per cent copper-nickel. With a 30 per cent furnace matte, one lining produced only 5.3 tons of bessemer matte.

As the amount of metal lost in furnace slag depends very much on the grade of furnace matte made, this pointed to the desirability of making lower grades of furnace matte with cleaner slags, throwing on the converters every year an increasing burden. The lower grade furnace mattes contained not only less copper-nickel, but also more iron; in a 40 per cent furnace matte, 1 lb. of copper-nickel is accompanied by 0.88 lb. iron; in a 30 per cent matte by 1.28 lb.; and in a 20 per cent matte by 2.4 lb. It is evident that lower grade mattes will require longer to blow than high grades, since the iron must be oxidized and the air capacity of the converters is fixed. One hour and five minutes is required to blow a 36 per cent furnace matte to produce a ton of 80 per cent bessemer matte, while one hour and fifty-five minutes is required for the same operation with a 30 per cent furnace matte. Further, since the amount of matte thrown out of the converter by he blast is about the same per hour, the capacity of the converters on low grade matte is reduced by reason of the greater amount of matte blown out during the longer period of blowing.

Basic-lined converters have been adopted in place of those just referred to, and considerable advantage has accrued from the change. The basic units are larger, and can handle larger quantities of matte. Owing to the manner of construction, there is practically no material slopped from the converter during the blow, and hence less furnace matte is required to produce a ton of bessemer matte. The slag is made lower in silica, which means economy in flux, and the converter slag contains less copper-nickel than in acid converting.

These basic converters are 37 ft. 2 in. long by 10 ft. diameter, outside measurement, running on four tread rings 12 ft. diameter. The opening for escape of gases during the blow is in the center of the cylinder, and there are no tuyeres directly under this opening. There are forty-four tuyeres, 1¼ in. diameter and 7 in. apart. The length inside the lining is 33 ft: 3 in.; the bottom is 2 ft. thick; the back or tuyere wall is 18 in. and the front wall 15 in. thick. The roof is a 12-in. arch, and the brick directly around the tuyeres is 24 in. thick. There are two openings in the front wall opposite to, but above, the tuyere line. Slag and matte are poured from these openings.

The basic converter takes an initial charge of about 60 tons of furnace matte. About 10 per cent of quartz rock, previously dried, is dumped into the converter and the blast turned on. Blowing is done entirely by the clock; the first slag is skimmed in from one-half to three-quarters of an hour, and while the slag is being poured off, 5 or 6 tons of furnace matte is poured into the converter. After the slag is poured, about 3 tons of quartz is added and the charge blown for another fixed time. The length of the blow, the amount of slag removed, the weight of matte added after each skim, and the per cent of flux required are all factors of the grade of matte and have to be determined by experience. The blowing and addition of matte is continued until the converter contains from 70 to 80 tons of finished product, after which the matte is cast into molds. This may require from 300 to 400 tons of furnace matte, and from 30 to 50 hours blowing time, depending on the matte grade.

Reverberatory Smelting

In order to provide a suitable method or treating an accumulation of flue-dust and fine ore, reverberatory furnaces were built in 1911. Briquetting and sintering had been tried on these materials, but without success, either on account of failure of the method or extravagant cost. The reverberatories

are interesting as being the first designed to burn pulverized coal. Pulverized-coal firing had been tried at Cananea, Mexico, and at the Highland Boy smelter in Utah, but the furnaces were not specially designed for this purpose.

The reverberatories at Copper Cliff are 112 ft. x 19 ft. hearth area. The extreme height inside is 6 ft.; the bottom is an inverted arch of magnesite brick with a spring of 12 in. The foundations were made by building a trestle about 14 ft. high, and pouring slag from this to build up within walls a solid block of slag 10 ft. high above the yard level. On this foundation the furnace walls were built, and slag was poured inside these to form a furnace bottom 2 ft. thick. Tunnels were formed in the slag foundation at either side of the furnace at the yard level, and through these two tunnels the melted converter slag is brought to the furnaces and matte taken back.

The hearth as formed by leveling up the poured slag with concrete, to provide an inverted arch of the same curve as the magnesite lining. On this one layer of fire-brick was laid flat, 2½ in. thick; over this 2 in. of ground chrome ore was laid, and on this the final bottom of 9 in. of magnesite brick, laid in a mixture of ground magnesite and linseed oil. Expansion strips of wood were laid between every six courses, allowing an expansion of ¼ in. to the foot. The tap hole is placed to retain about 12 in. of matte in the hearth, so that the bottom is always protected by a pool of matte.

Slag is removed at either side of the furnace, about 11 ft. from the front. The space at the front usually occupied by the slag door, slopes up gradually from the hearth to form a straight outlet for the products of combustion, which pass through dust-chamber flues to the stack.

The most interesting feature of the reverberatory practice is the method of firing. Coal is pulverized to about 200-mesh and delivered to bins at the end of the furnace. From these bins it is taken by five variable-speed screw conveyors 4 in. diameter, which deliver the coal to five burners, dropping it in front of the nozzles which carry air from a fan. The air blast sends the coal into the furnace in the form of a spray of dust which burns like fuel oil. Each burner can be run independently, and the amount of coal or air varied at will.

The *Monograph* from which the foregoing excerpt has been taken, contains also copies of the patents of the Mond, Hybinette, and Orford refining processes, which also have been noted in earlier issues of this journal.

Solvay Foundations

In connection with the fiftieth anniversary of the commercial birthday of the Solvay process, Ernest Solvay has made a number of splendid foundations. Our Berlin contemporary *Chemie*, probably the only daily chemical paper in the world, writes in its issue of September 26, as follows:

In the year 1861 Ernest Solvay, then 22 years old, an employee of a gas plant near Brussels, Belgium, applied for a patent for making soda from brine with the aid of ammonia and carbon dioxide. People thought then, however, that soda made by this process would be more expensive than Leblanc soda and no financier was willing to invest the money for starting a factory.

Only after many efforts, sufficient capital was raised to start a small experimental factory near Brussels. It soon appeared that the new process was essentially superior to the Leblanc process and in 1863 the first factory was built by Solvay at an expense of 136,000 francs ($27,200).

Today, after 50 years, the Solvay soda factories of Belgium and other countries have 35,000 employees and workingmen.

In connection with the 50th anniversary of the starting of the first factory, Solvay has made the following foundations and donations.

Donations were made to every official and employee as follows: Every official received a check to the amount of one monthly salary for every four years of service with the company, every workingman received ten francs and an extra check

to the amount of one monthly salary for every two years of service. Three million francs were given by the Solvay Works to the Workingmen's Pension Fund, so that every workingman, after 30 years work with the company, now receives a minimum yearly pension of 720 francs ($144.) Further, every workingman will have in future eight days' vacation with pay during the year. Two hundred and fifty thousand francs were donated to the Workingmen's University in Charleroi, 500,000 francs for prizes to be awarded by the International Congress of Hygiene, 500,000 francs were given to the chemical laboratory of Paris University, 500,000 francs to Nancy University for a new chair of electrical engineering, 300,000 francs to the hospitals of Ixelles, a suburb of Brussels, 100,000 francs were donated for fighting tuberculosis in Belgium and 75,000 francs for charity work in the little Belgian towns in which the Solvay works are located.

The German Solvay works have donated 3,500,000 marks for their Workingmen's Pension Fund. They also grant to their workingmen a vacation of eight days per year with pay, and have finally granted 250,000 marks for a scientific prize which is to bear the name of Ernest Solvay.

Russian Heavy Chemicals

(Special Correspondence from St. Petersburgh.)

Under the inspiration of the protective policy, which is the governing fiscal policy of Russia, several branches of the chemical industry have been made remarkably successful, the leading ones being the various soda and caustic soda factories. There is little new to be noted with regard to soda in Russia recently. The business, as is known, has developed to such an extent as to make Russian consumers quite independent of foreign sources of supply. This, however, is a luxury which is not particularly relished by the soda consumers, who find that for want of competition they have to pay an enormously higher price to the home producer than they would have to pay to the foreigner were the products of the latter admitted into the country duty free. But that is an old as well as a present-day story. It applies to all countries and need not be insisted on.

It is interesting, however, in connection with this situation, to state on behalf of the soda producers of Russia that whatever their motive may be, the price of soda in the country has been repeatedly reduced lately, so as to respond to a well-sustained agitation on the part of the consumers. As has previously been pointed out, a reduced price which stimulates an increased consumption reacts as a rule in favor of the producer, and figures have already been published and circulated showing that up till the beginning of this year, at all events, that policy had been a very successful one. So successful, indeed, has it been proved to be since these returns were issued that the demand, after having been about equal to the supply, has again outstripped it. The producers, however, anxious to keep control of the market have combined together for the purpose of erecting a fresh large soda factory to meet not only the present increased demands, but also the prospective ones over the next few years, and doubtless they will be successful in maintaining a fair equilibrium between supply and demand in Russia for some years to come with the aid of the new plant to be erected.

It is like repeating what is already world-wide knowledge to say that in bleaching powder, too, the Russian production has come to be quite equal to the demand and under the guidance of such houses as Solvay and Uschkoff, etc., it may be relied on to relieve Russian bleachers of all need to apply to foreign chemical works for supplies.

It is a strange thing in connection with the soda branch of Russian chemistry, which has developed so remarkably and so satisfactorily, that the production of salt in Russia should have progressed with very indifferent speed. It might almost be called a stationary industry, particularly if we take into account the immense strides the population of Russia is making in point of numbers and the naturally great increase there must

be in the demand for salt, even for domestic purposes. However, this is the fact. Certain of the salt fields are held to be strangled simply by the syndicates that have been formed to work them, as it was said, in consonance with the demand of Russian industry and the Russian householder. It is possible, though not likely, that a large quantity of salt produced escapes registration, and that the industry may be much larger than represented in official figures; but such is exceedingly unlikely. The suggestion simply arises because of one's inability to explain how it is that such an important essential industry as salt production, should be of such slow growth in a country where the population increases by leaps and bounds, where salt is abundant and where the development of industry, including heavy chemicals, has been extremely active over the last five or six years.

One need only make a cursory reference to the artificial fertilizer industry which has grown very rapidly, but by no means so rapidly as the awakened industrial conscience of the Russian farmer might have led one to expect. If the production at home is proceeding at a much greater rate than before, so is the importation movement, and as the Russian farmer realizes more and more the advantages to be gained from the use of fertilizers, it is obvious that the immense grain and root-growing area of Russia will call for far greater supplies of fertilizers than the home factories can hope to produce, excepting to the extent of, let us say, a fractional supply. It certainly will not be due to Russian chemical enterprise if the home production should increase very largely. It is an enigma, indeed, that in a country like Russia where great chemists are not scarce and where natural resources are not few, with an enormous demand, not at its own doors, but inside its own walls, the fertilizer industry, after a good many years of existence, should not have got beyond the initial stage or little better. It is frequently pointed out, and with reason, that although the raw material is there, it is not quite convenient for manufacturing purposes; but it strikes a student of national and international economics that if the German or English races had been the inhabitants of Russia the phosphates and pyrites of that country had long ago been turned to much better account than they are to-day.

Allied to the fertilizer business, of course, is the industry of coal coking which is extending so rapidly in the South—that is, in the Donetz basin, where the main iron industry of Russia is now located. The coking ovens there equipped with by-product recovery apparatus that might have been counted practically on the fingers of both hands a few years ago, now number thousands and the result is, it need not be pointed out, a relatively large supply of ammonia, which, with sulphuric acid (either produced at home or imported) is converted into sulphate on terms, however, that do not now very strongly tempt the South Russian farmer. Perhaps when he learns to count better he will appreciate its value and not judge it altogether by its invoice cost.

The significance, however, of the by-products recovery in South Russia extends beyond the field of fertilizers and comes closely into touch with the production of finer goods in the form of colors, etc. Time and again word has gone round that companies have been formed for the purpose of establishing factories to extract the more valuable elements from the by-products of the coking ovens, and one or two such have been established; reports on which, however, are exceptionally scarce, and are by no means sufficiently exhaustive to enable one to judge whether the higher chemical industries have got a hold on South Russia or no. One is sometimes led to the suspicion from the reports issued, that the results come rather from the laboratory of the works than from the industrial plant. All the same the raw material is there in increasing quantity; for all the records in coal production in South Russia have been easily broken both last year and this, as also of coke production. There must consequently be a great volume of valuable raw material recovered by the coke makers on which the more complicated chemical industries might easily rest.

From past experience one cannot hope that any immediate or proximate development of the chemical industry in Russia will result from Russian initiative. Anything that is done in that way will almost certainly be done by German chemists, who have developed from their point of view an excellent system of capturing the Russian market; namely the flotation of Russian companies with a predominating German financial element, for the purpose of constructing in Russia what are euphemistically termed Russian chemical companies; but which in reality are simply manufacturing branches of leading German chemical works.

Manufacture of Aluminium in France

An interesting summary of the present status of the manufacture of aluminium in France is given in *La Revue Electrique* of September 5, 1913.

Five French companies produce aluminium. These are the Société Electrométallurgique Française, the Compagnie des Produits Chimiques d'Alais et de la Camargue, the Société des Forces Motrices et Usines de l'Arve, the Société des Produits Electrochimiques et Electrométallurgiques des Pyrénées, and the Société d'Electrochimie.

These five companies have formed another company, *L'Aluminium Français*, which acts not only as sales agent but is also intended to carry out research work on the applications of aluminium and to devote itself to a propoganda to encourage greater consumption of aluminium. This company also manufactures in its plants at Selzaete, Belgium, and Mennessis, France, considerable quantities of alumina, sulphate of aluminium, etc. It is now erecting at Arrean, in the Pyrenees an aluminium factory and at Chambéry in Savoy, a rolling mill for manufacture of aluminium sheets, etc. At Kremlin-Bicêtre, near Paris, it has a factory for making tubes, etc.

The present status of the five constituent companies is briefly as follows:

Société Electrometallurgique Français.—This is Dr. Paul Héroult's company, formed in 1888—the "dean" of the French electrometallurgical companies. Its capital is 15,500,000 francs ($3,100,000). In the different plants of the company at Froges, La Praz, Saint-Michel-de-Maurienne, and L'Argentiere (Briançon) 65,000 to 70,000 hp are available during the greatest part of the year. Besides aluminium ingots, bars, wire, cables, tubes, aluminium cooking utensils, and pure alumina, the company produces ferro-alloys, electric steel (Heroult process), and carbon electrodes.

Compagnie des Produits Chimiques d'Alais et de la Compagne.—This company was founded in 1855 and its capital is now 10,500,000 francs ($2,100,000). Its plant at Salindres (Gard) was originally intended to manufacture soda by the Leblanc process, was later devoted successfully to chlorine manufacture, and began in 1861 to produce aluminium by the purely chemical process of Henri Sainte-Claire Deville. For 30 years it was the sole producer of aluminium. In 1897 it bought the Calypso aluminium plant and later equipped another hydroelectric plant, now producing "considerable quantities" of aluminium.

Société de Produits Electrochimiques et Métallurgiques des Pyrénées.—Founded in 1906, this company has now a capital of 6,000,000 francs ($1,200,000). Its Auzat plant has a capacity of 16,000 hp and its output is 6 tons of aluminium, 9 tons of chlorates or perchlorates, and 10 tons of calcium carbide or ferro-alloys.

Société des Forces Motrices et Usines de l'Arve.—Founded in 1895, this company has now a capital of 4,100,000 francs $820,000). Its Chedde plant has a capacity of 22,000 hp and its maximum output is 6 tons of aluminium and 20 tons of chlorates and perchlorates per day.

Société d'Electrochimie.—This company was founded in 1889 by H. Gall and A. de Montlaur for the electrolytic production of potassium and sodium chlorates and has now a capital of 10,000,000 francs ($2,000,000). In its numerous plants the company produces chlorates, aluminium, calcium and calcium hydride, sodium, and potassium and sodium cyanides and other chemical products.

Quantitative Spectrum Analysis

III—Industrial Application

By G. A. Shook

We have already considered some of the typical forms of colorimeters and spectrophotometers which may be used for the determination of the concentration of a colored solution, and we will now take up in detail the method of determining the constants necessary for the calculation of concentrations.

The theory of the colorimeter is so simple that it requires no special detailed study, but with the spectrophotometer the case is quite different.

As the esential points can best be brought out by concrete examples we will consider at length some data obtained on simple solutions like copper sulphate and cobalt chloride by means of one of the more complicated instruments, for instance, the Koenig-Martens polarization spectrophotometer. Salts of these solutions may be quickly and easily made up, and they are, therefore, good material for practice work.

A thorough knowledge of a particular instrument, combined with a little manipulative skill in using it, is almost indispensable for the execution of a complicated problem in colorimetry and such experience may be most easily obtained by beginning with the simplest cases.

The data used in this paper is obtained from observations made either by the writer or students of his laboratory, and may give some idea of the accuracy obtainable with limited experience.

Calibration of a Koenig-Martens Polarization Spectrophotometer

There are three general methods which may be used to calibrate a spectrophotometer, and the choice of either must be determined by the conditions under which the instrument is to be used.

(1) When only a rough estimation of the cencentration of a solution is required and when only a few samples of the particular substance are to be examined, then it is sufficient to make up a solution of known concentration and to determine the corresponding extinction coefficient for some definitely chosen color.

The absorption ratio may then be calculated, by means of which an unknown concentration may be readily determined.

Consider a special case: A 10 per cent solution of copper sulphate gave a reading on the Nicol scale of 43.2° (43° 12′) when the reading of the observing tube was 3.045. The color corresponding to this arbitrary number is green.

The extinction coefficient is therefore

$$e = \log \cot \phi = \log \cot 43.2 = 0.027$$

and the absorption ratio is

$$A = \frac{c}{e} = \frac{10}{0.027} = 370.$$

A 25 per cent solution gave a reading of 40.4°, and its extinction coefficient is therefore

$$e = \log \cot 40.4 = 0.070.$$

Hence the concentration by the optical method is

$$c = Ae = 370 \times 0.070 = 25.9 \text{ per cent.}$$

(2) If an accurate determination is required, then it is preferable to make up several solutions, varying in concentration over a range that will include all the concentrations of the unknown solutions.

Suppose, for example, that the samples to be tested range in concentration from 1 per cent to 5 per cent, then it is well to make up five solutions of 1, 2, 3, 4, 5 per cent concentration respectively, or, if they range from 10 per cent to 50 per cent, make up five solutions of 10, 20, 30, 40, 50 per cent concentration respectively.

The absorption ratio may then be determined for each of the five solutions and the mean may then be used for subsequent calculations.

The data of Table I was obtained from copper sulphate, the results being plotted in Fig. 1.

TABLE I.—OBSERVING TUBE 3.440 (RED) CuSO₄ (DILUTE).

Concentration in %	Rotation of Nicol φ	Extinction coefficient e	Absorption ratio A
0.25	42.8	0.033	7.58
0.50	40.5	0.069	7.25
0.75	38.7	0.096	7.81
1.00	36.6	0.129	7.75
1.25	34.1	0.169	7.47
1.50	32.2	0.201	7.50
1.75	30.0	0.239	7.33
2.00	28.1	0.272	7.37

Mean A, 7.51

Now, if we calculate, by means of the average value of A determined from the above data, the concentration of the solution made up to 2.00 per cent we obtain

$$c = Ae = 7.51 \times 0.272 = 2.02 \text{ per cent.}$$

This represents an average accuracy, and if we consider the 0.75 per cent solution whose absorption ratio deviates farthest from the mean, we obtain the following value for its concentration:

$$c = 7.51 \times 0.096 = 0.72 \text{ per cent.}$$

In all of these numerical examples, the concentration of one of the standard solutions is calculated by means of the average value of A merely to illustrate the method and to give a general idea of the accuracy obtainable.

Instead of taking the mean of the five values of A, for subsequent calculations, we may plot e against c on cross-
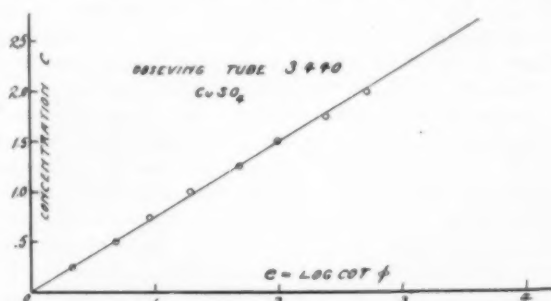
FIG. 1.—CALIBRATION CURVE FOR COPPER SULPHATE

section paper. Such a curve is shown in Fig. 1. The data used in plotting this curve was obtained from Table I.

According to theory this curve should be a straight line and should, moreover, pass through the origin of the axes, but, of course, all the points will not lie on a straight line due to unavoidable experimental errors. If the departure from a straight line is not greater than might be expected we may assume that Beer's law holds for the particular substance, at least for the range of concentrations chosen.

As long as this linear relation obtains, we are not concerned, at least in practice, about the ultimate cause of the color; that is, whether it is due to the molecule, the positive ion or the negative ion.

When such a curve is once constructed, then for future work it is only necessary to set the observing tube to 3.440 and to obtain the reading of the Nicol for the particular solution in question. If the log cotangent of this angle is obtained from a table, then the concentration may be read directly from the calibration curve.

(3) A third method is to construct a table giving the concentration corresponding to every circular degree on the Nicol scale. In this way any calculation whatsoever is avoided, it being only necessary to determine experimentally the angle of rotation of the Nicol, such that a photometric balance is obtained for the particular solution.

This expedient is justifiable whenever a large number of samples are to be tested. The greater the accuracy required the greater must be the number of standard solutions made up. Portions of such a concentration table, which were con-

structed from the above data upon copper sulphate are given in Table II.

TABLE II.—OBSERVING TUBE 3.440 (RED).
CuSO₄　　　　　　　　　　　　　　　10 mm. cell

ϕ	c	ϕ	c
20	3.29	31	1.66
21	3.12	32	1.56
22	2.95	33	1.40
23	2.78	34	1.28
24	2.63	35	1.16
25	2.48	36	1.06
26	2.34	37	0.92
27	2.19	38	0.80
28	2.06	39	0.69
29	1.94	40	0.57
30	1.79		

This table was constructed as follows: Take, for instance, the first angle 20°, log cot 20 = 0.439, hence

$$c = Ae = 7.51 \times 0.439 = 3.29.$$

Now, if a copper sulphate solution of unknown concentration produces a reading of 30° on the Nicol scale, its concentration is found directly from the table to be 1.79 per cent.

The best color, or wave-length of light, to use may be determined experimentally, if more than one standard solution is made up. If the solution is blue, then it will absorb more red light than blue light and consequently the red part of the spectrum should be used, provided that the sample is not too concentrated.

For if it is very dilute the blue part of the spectrum cannot be utilized, since the rotation of the Nicol, ϕ, necessary to produce a balance, will be so small that an accurate value of the extinction coefficient cannot be obtained.

If it is very concentrated too much light will be absorbed in the red and consequently a good balance cannot be made.

These effects are shown in a striking manner by means of the following data obtained from a blue salt, copper sulphate:

Weak Blue Solutions (CuSO₄).
Observing Tube 3.440 (Red).

CONCENTRATION IN PER CENT, c.

0.25	0.50	0.75	1.00	1.25

ROTATION OF NICOL, ϕ.

42.8	40.5	38.7	36.6	34.1

This gives a fairly wide variation of ϕ, so that accurate results may be obtained. For high concentrations the absorption in the green was found sufficiently great, as is shown by the following data:

Strong Blue Solutions (CuSO₄).
Observing Tube 3.045 (Green).

c 10	15	25	30	45
ϕ 43.2	42.1	40.4	38.6	36.9

In like manner for weak red solutions one cannot employ the red part of the spectrum, as is seen from the following results:

Weak Red Solutions (CoCl₂).
Observing Tube 3.540 (Red).

c 1	2	3	4	5
ϕ 43.6	42.6	42.1	41.5	40.7

The difference in the reading of the Nicol in this case is obviously not sufficient for accurate work.

The green part of the spectrum was then used for the same solutions with the following results:

Weak Red Solutions (CoCl₂).
Observing Tube 3.000 (Green).

c 1	2	3	4	5
ϕ 41.5	35.6	31.9	27.7	22.9

However, for strong solutions of cobalt chloride the red part of the spectrum is best adapted, as shown in the following table:

Strong Red Solutions (CoCl₂).
Observing Tube 3.540 (Red).

c 10	15	20	25	30
ϕ 37.4	35.7	32.9	30.6	27.9

To determine the best position of the observing tube, fill the cell with the weakest solution and obtain a rough balance in different parts of the spectrum, noting the reading of the observing tube for each position. Repeat the same operation with the strongest solution and then choose the position of the observing tube which gives the greatest change in the reading of the Nicol for the two solutions.

What has been said in regard to calibrating the Koenig-Martens instrument may be applied to any spectrophotometer. In the case of the double-slit instrument, one is concerned with the width of a slit and not with the rotation of an analyzing Nicol. Consequently the expression for e will be different.

For work where extreme accuracy is not required the polarizing instrument has this decided advantage over other types, namely, that the relation between the log cotangent of the angle made by the analyzer and the angle itself is approximately linear at least from 45° down to 25°. This simply means that instead of looking up the log cotangent of ϕ, each time, we may simply use ϕ.

To illustrate, the data obtained on copper sulphate, Table I, was used to plot a curve with c and ϕ as coordinates and it is seen from Fig. 2 that the points lie on a straight line which passes through 45°, where the concentration is zero, as would be expected, for if the concentration is zero the fields are equally bright and therefore the Nicol must make an angle of 45°. The extinction coefficient then assumes the simple form

$$e = 45 - \phi$$

whence

$$c = Ae = A(45 - \phi)$$

and

$$A = \frac{c}{45 - \phi}$$

The absorption ratios for the various concentrations are given in Table III.

TABLE III.

Concentration in Per Cent.	Absorption Ratio.
c	A
.25	0.114
.50	0.111
.75	0.119
1.00	0.119
1.25	0.115
1.50	0.117
1.75	0.117
2.00	0.119
	Mean A, 0.116

The 2 per cent solution gives a reading of 28.1 and therefore by this approximate method its concentration is

$$c = Ae = 0.116 (45 - 28.1) = 1.96 \text{ per cent.}$$

An inspection of the two curves, Fig. 1 and Fig. 2, will show at once that for the particular data at hand the points obtained by plotting c and ϕ will not deviate from a straight line any more than the points obtained by plotting c and log cot ϕ.

Of course, it is not necessary to plot a curve if one calculates A for each concentration, for if the variation in the values of A is not greater than might be expected from experimental errors then the exact method need not be resorted to.

If the initial balance is not carefully made then A will not be

constant for different values of e, although a straight line may be obtained by plotting c and e. The straight line thus obtained, however, will not pass through the origin.

If it is found that A is not constant for a particular set of standard solutions it is best to plot a curve before concluding that Beer's law does not hold, for the variation in A may be due only to an error in the "zero" reading.

A rule for determining roughly the best wave-length or color to be used when this particular instrument is employed may now be formulated.

Since the entire angular change of the Nicol should be about 20°, the reading on the Nicol scale for any particular concentration may be calculated approximately. Let us suppose we have a range of concentrations extending from 1 to 5 per cent.

It has been shown that

$$c = Ae = A (45 - \phi)$$

and it follows that

$$c/e = c'/e' = c''/e'' \ldots = \text{constant.}$$

Now, if $c = 1$ per cent and $c' = 5$ per cent, then since the reading of the Nicol for the 5 per cent solution should be
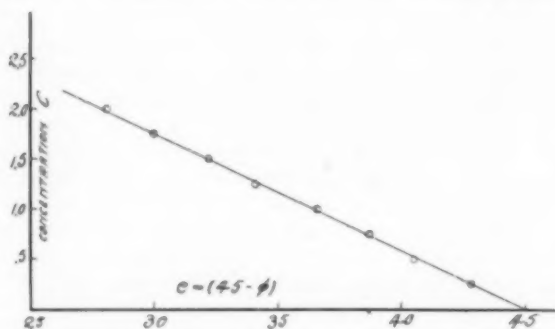

FIG. 2.—CALIBRATION CURVE FOR COPPER SULPHATE (APPROXIMATE METHOD)

about 25°, the reading for the 1 per cent solution must be about 41° for

$$c/c' = 1/5 = (45 - \phi)/ (45 - 25)$$

or

$$\phi = 41°.$$

Hence, for the five concentrations, the corresponding readings on the Nicol scale must be approximately as follows:

CONCENTRATION IN PER CENT c.				
1	2	3	4	5

READING OF NICOL SCALE ϕ.				
41	37	33	29	25

The method of procedure would be as follows: Fill the cell with any of the five solutions, say the 3 per cent solution, and set the Nicol to 33°. Now, rotate the observing tube until an approximate balance is effected and note the reading of the observing tube scale.

For example, five concentrations of potassium permanganate were made up as follows: 0.01, 0.02, 0.03, 0.04, and 0.05 per cent. In order to make an approximate balance for the 0.03 per cent solution, it was necessary to move the observing tube to 3.400 (red) when the Nicol was set at 33°.

The following readings were then obtained for the five solutions:

CONCENTRATION c.				
0.01	0.02	0.03	0.04	0.05

READING OF NICOL SCALE ϕ.				
40°	35.8	32.5	28.5	25.1

This general method of determining the proper color may always be applied to the Koenig-Martens instrument whatever

method is used to calibrate it. If one wishes only approximate results and makes up only one standard solution, then the best color may be readily found by the above method.

Concentration of Colorless Solutions

The concentration of a colorless solution may sometimes be determined by means of a spectrophotometer if a reagent can be added which will produce a color or which will cause the solution to become turbid.

For example, if a solution of barium chloride is added to a solution of potassium sulphate, a fine white precipitate is formed by the insoluble barium sulphate. Since all the other salts in the solution are soluble and, moreover, colorless, the density of the precipitate, that is, the number of absorbing molecules per c.c. of the absorbing medium is directly proportional to the concentration of the potassium sulphate provided an excess of the barium chloride is added.

As long as the precipitant is colorless and soluble an excess of it merely plays the rôle of a solvent. By means of the spectrophotometer we can get a measure of the absorption caused by the precipitate and hence it is readily seen that such an instrument may be employed for this class of analysis.

When the percentage of potassium sulphate in any unknown solution is once determined, then it is only a matter of calculation to obtain the per cent of SO_4, S, or O, etc.

In coal analysis we are concerned with the amount of sulphur present, while in water analysis with the amount of SO_4. We might, of course, add an excess of the sulphate and then determine the percentage of chlorine in barium chloride, etc.

We will now consider a few examples. The average value of the absorption ratio, A, determined from three solutions of potassium sulphate was 0.0577. The solutions were made up to 0.02, 0.01 and 0.005 per cent of SO_4.

For the solution made up to 0.005 per cent the extinction coefficient was found to be equal to 0.089 and, therefore, the optical method gives, for its concentration,

$$c = Ae = 0.0577 \times 0.089 = 0.00512 \text{ per cent.}$$

In the same manner data was obtained for the determination of the percentage of chlorine in sodium chloride. A silver salt was used as a precipitant. In order to keep the precipitate in suspension long enough to make the necessary readings rather dilute solutions had to be used. The following data was obtained:

Estimation of Cl in Na Cl by means of the absorption of Ag Cl.

Concentrations based on the per cent of Cl.

c	0.0570	0.0429	0.0286	0.0143
ϕ	38.5	40.6	42.2	43.8

The average value of A from the above table is 0.651.

For the 0.0286 per cent solution the optical method gives the following results:

$$e = \log \cot 42.2 = 0.043$$

and therefore

$$c = Ae = 0.651 \times 0.043 = 0.028 \text{ per cent Cl.}$$

We may consider one more example of a similar character, namely, the estimation of calcium in calcium chloride (Table IV). In this case ammonium oxalate is added to the calcium chloride solution and the absorption of the insoluble calcium oxalate is taken as a measure of the concentration of the calcium.

This is a good example of the ability of such an instrument to detect the presence of very small quantities. The concentrations are based upon the per cent of calcium.

TABLE IV.—ESTIMATION OF Ca IN Ca Cl.

c	ϕ	e	A
0.00125	42.4	0.039	0.0320
0.00250	39.0	0.092	0.0272
0.00500	33.4	0.181	0.0362
0.01000	24.2	0.347	0.0289
		Mean A,	0.0311

The concentration of the 0.01 per cent solution is from the above value of A:

$$c = Ae = 0.0311 \times 0.347 = 0.0108.$$

The estimation of iodine in potassium iodide is a good example of the determination of the concentration of a colorless solution (Table V).

Iodide of potassium is colorless, and in order to develop a color a reagent was added which would liberate the iodine and not produce an additional color. Dilute nitric acid was used in this case. We might use $K_2 C_2 O_7$ to liberate the iodine, but this reagent gives an additional color. Alcohol was also added to hold the liberated iodine in solution.

TABLE V.—ESTIMATION OF I IN KI.
Concentrations based on per cent of I.
Observing tube 3.000 (Green).

c	ϕ	e	A
0.25	20.5	0.427	0.586
0.125	31.4	0.214	0.585
0.0625	37.1	0.121	0.516
0.0313	39.7	0.081	0.387
0.0156	42.4	0.039	0.402

The data of Table VI upon resublimed iodine dissolved in alcohol is given to show the systematic variation of the absorption ratio A. This change in the value of A is probably due to the oxidation of the iodine into hydriodic acid which is colorless.

Beer's law evidently does not hold in this case and accurate results could not be obtained except for a limited range of concentrations.

TABLE VI.—ESTIMATION OF IODINE IN ALCOHOL.
Observing Tube 3.000 (Green).

c	ϕ	A
0.25	18.8	0.535
0.125	29.5	0.507
0.0625	35.9	0.446
0.0313	39.4	0.367
0.0156	41.9	0.331

The absorption ratio A can almost always be determined by means of data obtained from controlled experiments. For instance, in order to determine the percentage of P_2O_5 in a sample of fertilizer it is not necessary to have a number of samples of fertilizer in order to determine A. This may be illustrated by an example.

The following method of preparing the solutions and the sample of fertilizer to be tested is due to Professor Spitzer, of Purdue University, who has perhaps done more work in colorimetry than any other chemist in this country.

The solutions were prepared from a standard solution of calcium phosphate. The phosphate was first precipitated as ammonium phosphomylbdate. This insoluble precipitate was then washed with dilute nitric acid, to free it from the soluble ammonium phosphomylbdate, and finally dissolved in a dilute solution of potassium hydroxide.

Hydrogen sulphide gas was then passed through this solution, causing it to turn to a clear yellow color. The color depends upon the concentration and it varies from yellow to brown. This solution was then diluted according to the percentage of P_2O_5 required. The data for six different concentrations of P_2O_5 is given in Table VII.

TABLE VII.—ESTIMATION OF P_2O_5 AS MOLYBDIC SULPHIDE.

c	ϕ	e	A
0.00078	44.1	0.014	0.0557
0.00156	42.0	0.046	0.0340
0.00312	40.1	0.070	0.0445
0.00623	35.6	0.145	0.0430
0.0125	28.8	0.260	0.0480
0.02500	17.5	0.502	0.0499
		Mean A,	0.0459

A sample of fertilizer secured from the Agricultural Experiment Station was made strongly ammonical and then a slight excess of nitric acid was added according to the directions of the official methods of analysis.

This solution was heated to about 80° C. and an excess of ammonium molybdate solution was then added and the heat continued for an hour.

The precipitate, phosphomolybdate of ammonia, was then collected on a filter and well washed with dilute nitric acid to free it from any traces of molybdate solution.

It was next dissolved in a boiling solution of 5 per cent potassium hydroxide. Sulphurated hydrogen was then passed through this solution for twenty minutes, causing it to assume a deep red color due to the formation of the molybdate sulphide

The solution gave a reading of 30° on the Nicol scale, whence its extinction coefficient is

$$e = \log \cot 30 = 0.239$$

and its concentration is

$$c = Ae = 0.0459 \times 0.239 = 0.0110.$$

But 125 c.c. of the original solution represents 1 gram of fertilizer, hence the per cent of P_2O_5 in the fertilizer is

$$c = 125 \times 0.0110 = 1.37 \text{ per cent.}$$

The value obtained by the station was 1.51 per cent. Professor Spitzer has carried out a number of such determinations and his average error is considerably less than this.

It is sometimes more convenient to use actual samples for making up standard solutions than to attempt to make, as it were, artificial standards. For instance, in the determination of the per cent of combined carbon in steel by colorimetric methods, one can obtain from the U. S. Bureau of Standards samples of steel which have been accurately analyzed by chemical methods. These samples range in carbon content from a few tenths of 1 per cent up to several per cent.

We will now consider at length a practical example. A 1 per cent solution of iron was made from a sample of malleable iron containing 3.40 per cent of combined carbon. This solution was then diluted so as to make four more solutions of different concentrations. Data was then obtained upon these five standard solutions by means of a Lummer-Brodhun spectrophotometer of the ordinary form.

The importance of an accurate initial balance is clearly brought out by the first set of data obtained upon these iron solutions.

Both slits were set at 30 and a cell containing water was placed in front of one slit. The lamps were then adjusted until the two photometric fields appeared equally bright and without making any further check upon this balance both slits were opened to 100. The data given in Table VIII was then obtained.

TABLE VIII.—ESTIMATION OF CARBON IN IRON.
Concentrations based upon per cent of iron.
Observing tube 72.0 (Green).

c	R	e	A
.125	58.9	0.229	0.546
.250	51.0	0.292	0.857
.500	43.0	0.365	1.37
.750	33.6	0.474	1.58
1.000	27.0	0.567	1.77

R is the reading of the slit and therefore

$$e = 2 - \log R.$$

One might infer, at first sight, that Beer's law does not hold in this case, since A varies continuously.

If, however, c is plotted against e it is readily seen that a linear relation obtains, hence we may infer that the law does hold.

The cell filled with water, was again placed in position and an accurate balance was obtained by adjusting the slit which was not covered by the cell. The average reading of the slit was found to deviate considerably from 100, as might be expected.

It was then set at 100 and the other slit (i. e., the one covered by the cell) was carefully adjusted until a balance was effected.

To make sure that the balance was accurate the first slit was again reset a number of times and the average reading was found to be 99.88. The other slit, which read 125.2, was left intact and the data of Table IX was obtained upon the same solutions.

TABLE IX.

c	R	e	A
0.125	88.9	0.051	2.45
0.250	76.4	0.117	2.14
0.500	62.9	0.201	2.49
0.750	50.0	0.301	2.49
1.000	38.0	0.420	2.38

It is seen from the above table that the variation in A is not more than might be expected from experimental errors.

The second solution, 0.25 per cent, was slightly turbid, consequently its absorption ratio A is too low and it should, therefore, not be considered in determining the mean A.

The data of Table X, for the determination of the per cent of sulphur was also obtained by means of the same instrument.

Barium sulphate was precipitated from a solution of potassium sulphate by adding an excess of barium chloride. Due to the rapid precipitation of the barium sulphate only a few readings can be obtained before the solution becomes non-homogeneous.

If the cell is shaken and then allowed to stand a few seconds the solution will again become homogeneous and the readings may be repeated. In this manner it was possible to obtain fairly consistent results.

TABLE X.—ESTIMATION OF SULPHUR AS BARIUM SULPHATE.
Concentrations based upon per cent of sulphur.
Observing Tube 72.0 (Green).

c	R	e	A
0.005	69.9	0.155	0.0323
0.010	55.3	0.257	0.0389
0.015	32.5	0.488	0.0307
0.020	28.3	0.548	0.0366
		Mean A,	0.0346

It is thus seen, from these few examples, that any first-class spectrophotometer may be universally used for the determination of the concentration of a colored or turbid solution.

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The Leadville Pumping Association, organized to unwater the mines of Fryer hill, Leadville, announces that it has obtained signatures from over 85% of the owners of Fryer hill ground, agreeing to the terms of the proposed scheme of unwatering and operating the mines.

The International S. & R. Co. now has five blast furnaces in operation on lead ore at the Tooele plant. A feature of construction of furnaces at this smelter is the use of two rows of jackets, the advantages of which are that accretions are less likely to form, and are more easily barred when they do form.

Commercial Relations of the United States.—A concise volume, which contains statistics showing the foreign trade of each country of the world during 1911 compared with the previous year, has just been issued by the Bureau of Foreign and Domestic Commerce at Washington. It shows the principal articles and their value entering into the trade of each country and gives itemized figures for the imports from and exports to the United States. The statistics were prepared by American consular officers, and supplemented by other official data. In addition to trade statistics, the grain crops and mineral output of the principal countries are given, thus presenting in compact form the principal features upon which the commerce and industries of the foreign countries depend. Copies of the book may be obtained from the Superintendent of Documents, Washington, D. C., for 35 cents each.

Condensation of Zinc Gas to Liquid, in the Presence of Inert Gas.

By F. L. Clerc

The difficulty in collecting distilled zinc in the liquid state, reported by numerous experimenters with new furnaces, indicates that the problem of condensing zinc from a gas to a liquid, in the presence of inert gases, is one of general interest. The zinc obtained has been solid, in the form of powder, and more or less oxidized. It is usually described as "blue-powder." In a former paper I have shown how indefinite this term is, and how important it is that there should be a more exact classification of the various products. Some zinc in solid powder is produced in all industrial zinc furnaces, and it is not probable that any furnace can be designed which will entirely avoid its production, or will reduce it to negligible proportions.

The problem of immediate interest is, to get as much of the zinc in the liquid state as possible; and, what is quite as important, to prevent the zinc dust, which is invariably formed, from obstructing the apparatus and interfering with or even putting a stop to the operation. The rapidity with which zinc gas is evolved by some furnaces, is given as a reason why the zinc is not collected from them as a liquid. It is probable that apparatus could be devised to effect condensation in spite of a rapidity of volatilization far exceeding that observed in any furnace working on an industrial scale, if uniformity in the rate of volatilization could be attained. That is, we should rather modify the relative size of condensers, than restrict the rate of distillation to conform to present practice. The real difficulty comes from the irregularity, and not from the rapidity, with which zinc gas is evolved.

It has been generally known for a long time that both chemical and physical causes contribute to the formation of zinc dust. Mr. W. McA. Johnson has proposed the names "physical" blue-powder and "chemical" blue-powder, to distinguish forms of different origin. The suggestion has value, if only to keep in mind the joint action of both chemical and physical forces. If he will still further inform us how these two forms can be distinguished, one from the other, and whether he has observed intermediate forms, he will furnish criteria by which we can diagnose the cause of any particular failure, by examining the blue-powder produced.

The Effect of Oxidation

In the meantime, admitting that both chemical and physical causes often act together, it may be well to consider them separately. The chief chemical cause assigned for the formation of blue-powder is oxidation. But there is a great variation in the amount of oxide present in different samples of commercial blue-powder, and it is difficult to know with certainty that oxidation has not occurred after the blue-powder has formed; that is, during its removal from the condenser and prior to the analysis. If it is argued that the least amount of oxide present in commercial samples is sufficient to account for the formation of the powder, and that greater amounts found in other samples were formed after solidification, this question can be tested by experiment.

In the sample of blue-powder mentioned in my former article, referred to above, which was melted in a Berzelius arsenic bulb, there was evidently not enough oxidation to prevent coalescence. Moreover, Dr. E. Haanel has informed me that he has melted tons of blue-powder, after mixing it with carbon in proper form and amount. It is not probable that any zinc oxide was reduced in this operation. The explanation is that the air between the dust particles acted on the carbon at about the temperature of melting zinc, forming carbon monoxide which prevented further oxidation of the zinc. Evidently, then, there was not sufficient oxide present originally to prevent melting the blue-powder. Some other contributing cause than oxidation must, therefore, be found for the formation of blue-powder. The question arises: Is it possible by chemical analysis to determine what amount of oxidation will

prevent coalescence, or to devise some other test to distinguish "chemical" from "physical" blue-powder?

The oxide formed, being lighter than the metal, is supposed to float on the surface of the liquid globules, and, when present in sufficient amount, to form a protective coating over them. It is interesting to consider how the amount of oxide required to form a protective coating over all the surface of the globules, will vary with their size. The volume of a given weight of liquid zinc is the same, other conditions being equal, whether it exists as one sphere or any number of spheres; but the combined surface of the smaller spheres will exceed the surface of the single sphere. It follows that an amount of oxide just sufficient to paint a single sphere, will not effectively cover two or more spheres, the combined volume of which is equal to that of the larger sphere. Evidently then, if some oxide is present, as condensation progresses in the Belgian condensers and the globules grow by accretion, some size must be reached at which the oxide present is sufficient to form a protective coating. Does this indicate an upper limit to the size of the globules formed, in condensing zinc gas in the presence of some zinc oxide?

Some plausibility is given to this hypothesis by the rather constant percentage of the weight of commercial blue-powder of widely different origin, which will pass through a 200-mesh sieve. I shall, however, offer a different explanation of this uniformity. Other chemical forces than oxidation may contribute to the formation of blue-powder. The presence of cadmium, arsenic, antimony, tellurium, selenium or sulphur may have some effect; but none of them can be considered as generally acting.

Mechanical Forces Considered

The mechanical forces which may produce blue-powder can be considered under two headings: First, atomic and molecular forces; and, second, mechanical forces.

First: Atomic and Molecular Forces.—The force expressed in heat units required to overcome the atomic and molecular forces which hold zinc in the liquid state, is a direct measure of the force which tends to condense it, for on condensation the same amount of heat is given out. But in order that these atomic and molecular forces can come into play, the separate particles must be brought into close proximity. It has been concisely stated that condensation is essentially a cooling operation; but simple withdrawal of heat will not suffice to bring the particles together to its original liquid state.

Condensation a Complicated Phenomenon

Experiments with liquids which boil at a lower and more easily controlled temperature, show that condensation is a very complicated phenomenon, and that the liquid globules increase rapidly in size after their presence in the gas is indicated by the appearance of a nebular zone. Their formation is assisted by the presence of minute solid particles, called nuclei, throughout the cooling gas, around which condensation occurs. When they attain a certain size they fall by gravity at a measurable rate, and collect as a liquid mass at the bottom of the containing vessel. The walls of this vessel act similarly to the nuclei, and doubtless the nature of the walls and of the liquid have some effect.

It is reasonable to suppose that zinc gas in condensing behaves similarly; and that for a complete explanation of condensation we must have a perfect understanding of the laws of diffusion, viscosity, and vapor tension of gases, and of the surface tension, capillarity, adhesion and cohesion of liquids; for all of these forces are involved, either in the collection of liquid globules on the walls of the condenser, or in their union with the liquid mass. Some of them have to be overcome in the operation of condensation; others assist it. As examples of coalescence, distinct from condensation, we may cite the gathering of scattered globules of mercury; the coming together of rain drops on a window pane; and the rolling of drops of water over a wave surface of a larger mass of water, particularly if the latter be salt or muddy, before they merge themselves into the greater mass.

It is fortunate that we do not have to take account of all of these forces, the laws of which are but little known, for the reason that we know they act when the particles are brought close enough together, and that they always act the same way under the same circumstances. Furthermore, we know that a large percentage of zinc gas condenses itself into a single liquid volume, in the small space of a Belgian condenser, and within the very short time it takes the accompanying gas to traverse it.

Effect of Gravity and Mass Action

Second: Mechanical Forces.—The extraneous forces which I shall consider as acting on the zinc globules and accompanying gas, which are to be relied on to bring the zinc atoms and molecules into such proximity that intermolecular forces can come into play, are gravity and mass motion. The action of these forces, while not more mechanical than the action of any physical force, is subject to well-knows mechanical laws. Mass motion is due to change of volume by the addition or subtraction of heat; that is, by change of temperature, or change of state accompanying volatilization or condensation.

Gravity, of course, is constant; but it is opposed by several resistances. Here is not a case of bodies falling or moving through a vacuum. The solids and liquids fall through a moving fluid, the density of which varies with the temperature. The surface friction of the globules and the viscosity of the fluid all oppose motion. This opposition, however, is not directive; its effect is simply to lengthen the time required to traverse a given space.

In designing a condenser, we can extend indefinitely the time during which condensation is possible, and thus allow time enough for gravity to perform the same work in a large condenser which it accomplishes in the Belgian condenser. Likewise, in the motion produced by change of volume, we need not consider opposing forces; a time allowance can be made. The relative direction and velocity of these two motions determines the path of the globules, and brings them together against obstructing surfaces. The importance of a uniform current of gas, in a direction favorable to bringing the globules within the range of action of molecular forces, is thus very strongly in evidence. Whatever may be the rate of evolution of zinc gas, the condenser may have a cross-section to give a proper velocity and direction to the issuing gas current.

Range of Temperature Unalterable

There is, however, one condition which cannot be varied, whether the condenser is large or small, and that is the range of temperature within which condensation is possible. The condenser must be kept at a temperature between the melting and boiling points of zinc, and the gases should cool gradually from their entrance to their exit. It is readily admitted that such close regulation is much more difficult in the case of a large condenser than of a small one. In the case of the Belgian condenser, more than enough heat is carried in by the gases to maintain this temperature under normal working conditions. The same proportion of heat should be supplied by the gases to a large condenser. The Belgian condenser receives heat from the front of the furnace, and radiated heat from the open mouth of the retort. Both condensers lose heat by radiation. A rapid and uniform rate of distillation should lessen the percentage loss from this source. In this connection, also, it must be remembered that the ratio of the surface to the volume is much smaller in the case of a large condenser than of a small one. The effect of these different conditions is to offset each other to some extent. But if the loss of heat in the large condenser is too rapid or too local, precautions must be taken against this, and if necessary, external heat must be applied. This is no more irrational than is the reverse operation of cooling furnace walls with air and water-jackets.

The problem of regulating the temperature of a condenser resolves itself into three simple problems: First, getting it hot enough at the start; second, conserving the heat during normal working, so that the condenser may be as large as

practicable; and third, supplying or dissipating heat locally as desired. The drawing in Fig. 1 will express these ideas applied to a concrete case. It is a condenser designed for use with a copper-bottom retort working continuously.[2] This condenser should have in front a removable panel with its own lining, in addition to a removable cover to afford ready access to the interior; and it should be nearly red-hot when it is attached to the retort. I think the cut and references will be readily understood, and that the ideas may be applicable to condensers designed for other forms of continuous zinc furnaces.

Suggested Design of Condenser

The length of this condenser will be equal to the greatest length of the retort, and its capacity will be regulated as nearly
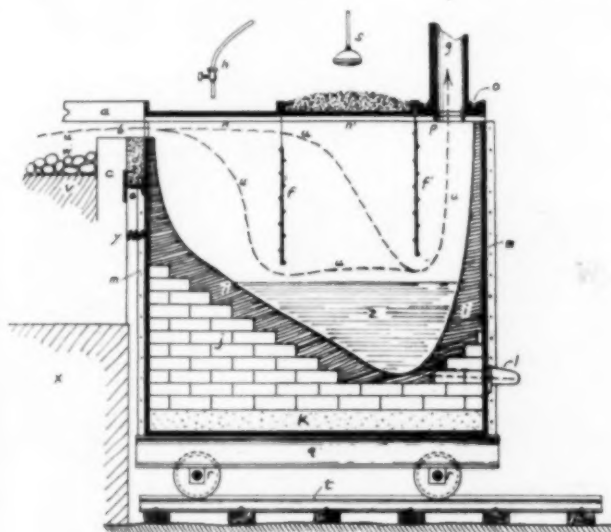
CROSS SECTION AT RIGHT ANGLES TO RETORT
(Length of condenser equals greatest length of retort)

· REFERENCES ·

a- Cover of retort.
b- Entrance to condenser.
c- Outer wall of retort.
d- Sand joint.
e- Rib and wall plate.
f- Diaphragm of wire-glass with passage top and bottom.
f'- Diaphragm of wire-glass with passage at bottom.
g- Outlet to washer.
h- Gas burner for heating top of condenser with washed gas.
i- Inner lining of refractory material rammed and burned in place.
j- Bottom laid in with blocks.
k- Coarse insulating material.
l- Spout of tap.
m- Sectional casing of cast or wrought plates.

n- Top plate, lined, in front of first diaphragm.
n'- Top plate, lined, in front of second diaphragm.
o- Trough for fusible metal.
p- Top plate, lined, under outlet to washer.
q- T-beam supporting condenser.
r- Wheels and axles.
s- Water spray (when needed).
t- Track (for changing condensers).
u- Path of gases.
v- Copper bottom of retort.
w- Briquetted charge in retort.
x- Foundation of retort.
y- Spring clutch holding condenser in place.
z- Bath of molten zinc.

FIG. I.—ZINC CONDENSER

as may be to the normal working of the furnace. The gas issuing from the condenser will be nearly pure CO, and of high calorific value. It will be needed to dry and heat up the condensers, and occasionally to blow the residues out of the retort. It will carry out an amount of blue-powder too important to be lost, and which should be recovered by washing the gas. The washed gas should be carefully stored. Its volume will be relatively small; for each ton of zinc reduced there will be formed 863 lb., corresponding to 10,960 cu. ft. of CO, at standard conditions of temperature and pressure. I can suggest no better washer for this purpose than is shown in Fig. 2, which is reproduced from my Belgian patent of July 26, 1876.

[2] This journal, Aug., 1912, page 463.

Washing the Carbon Monoxide Gas

An iron tank, divided near the bottom into eight downward-pointing compartments, each of which has its own discharge cock, is partly closed at the top by an iron cover, the deep flanges of which are notched to fit the sloping sides of the bottom compartments. The gas is led under the cover through three downtake pipes, each of which receives a shower of water drops admitted, above the entrance of the gas, through finely perforated plates, from a tank containing filtered water. This water, rising between the tank and the cover, prevents the escape of gas. The gas under the cover escapes through the small pipes which encircle the downtakes, and is collected in the gas box above. The downtakes pass through sleeves
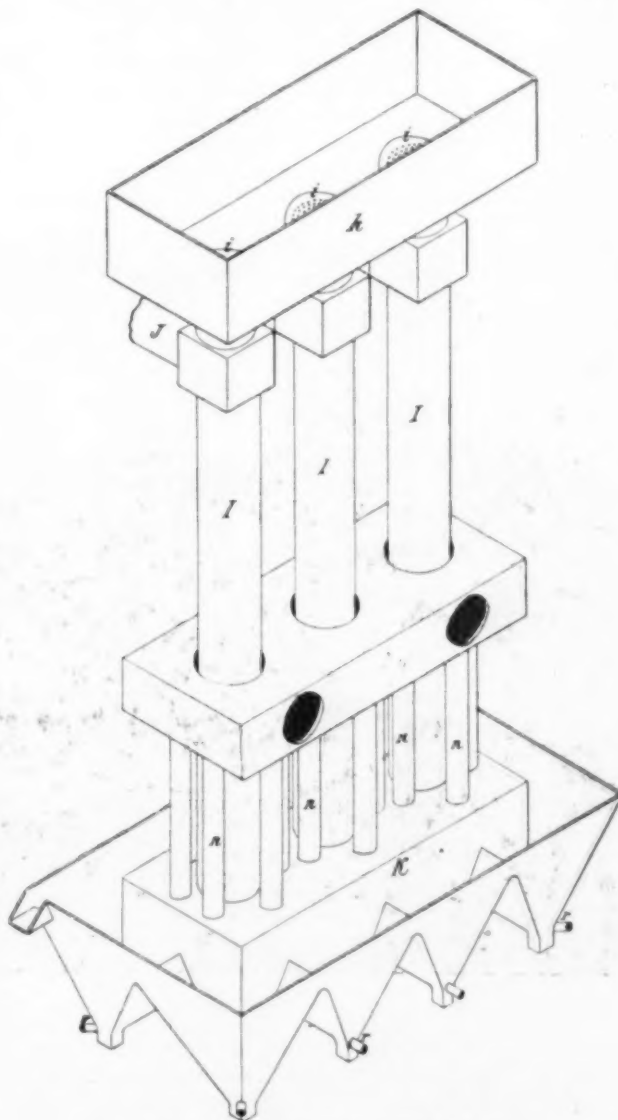
FIG. 2.—WASHER FOR RETORT GASES

inserted between the top and bottom of the air box. The object of this construction is to get as equal distribution of gas as can be had by axial symmetry. The object of the small tubes is to cool and dry the washed gas, and to return to the tank any fume which may adhere to them. Anyone who has thrown very fine blue-powder into water, hot or cold, knows how quickly it settles to the bottom.

The underlying idea of this washer is to avoid eddies and opposing currents in the gas. The falling drops have the same direction as the gas, and will help to regulate the draft. The top of each downtake can be closed by a sagging disc of rubber, which can be lowered to close some or all of the holes in the perforated plate. The water can thus be shut off instantly. Quickly acting dampers should be inserted in the pipes lead-

ing from the retort, so that the operator can quickly close connection between the condenser and the washer. The washed gas should be stored in a gasometer. No washer will prove satisfactory unless it can be shut off from the condenser as quickly as a gas burner can be turned off. I believe that every one will agree with me that the size of the grains of blue-powder carried out of the condenser is limited by the size of particles of zinc which can be transported by the force of the current at its point of exit.

Estes Park, Colorado.

Gold-Milling Progress in California
By Al. H. Martin

The modern stamp mill was evolved from California practice, but California metallurgists have been the most conservative in adopting methods developed by operators in other fields. Stamp-crushing, amalgamation and concentration on blanket or canvas tables completes the ore treatment in a majority of the leading gold-mining districts of the State, and it has only been within the past five years that the cyanide process has been employed to any extent. But recently a more

FIG. 1.—DARROW-HAMBRIC SLIME CONCENTRATOR

progressive spirit has developed, with the result that thousands of tons of tailings that were formerly wasted are now yielding good profits, and ores that were deemed too refractory to warrant consideration have become sources of excellent profit. Conservatism still reigns in most of the districts, but the stronger companies are gradually adopting the more advanced methods.

Cyaniding at the Black Oak

As an example of the new era in California gold-milling, the recently erected plant of the Black Oak Mining Co. commands particular attention. It is the first all-sliming cyanide plant ever built in the State, and is located at Soulsbyville, Tuolumne county, in the eastern portion of the Mother Lode gold-bearing zone. The mine has been a heavy producer for years, with attention largely confined to the higher-grade quartz. The old mill contained 40 light stamps, and crushing was followed by amalgamation and concentration with vanners and canvas tables. The extraction was never good and thousands of dollars' worth of high-grade tailings were washed to waste every

month, but no attempt was made to secure a better yield until the present owners took charge.

The new mill embraces twenty 1250-lb. stamps, in place of the twenty 750 and twenty 850-lb. stamps formerly employed. The ore is very hard, silicious, and of high milling grade. The crushed product is trammed to the small mill bin, designed to enable a rapid and accurate measurement of bin contents at any time desired. Challenge non-suspended feeders serve the stamps. The mortars are of the high, rapid-discharge type, weighing 8500 lb. each and mounted on foundations composed of concrete made from selected quartz and granite. These foundations were carefully moulded and have given splendid service. Crushing is done in cyanide solution through Tyler ton-cap screens and the pulp delivered to a Dorr duplex classifier. From this machine the coarse product passes to a 5 by 18-ft. tube-mill, and the slime overflow proceeds to the tanks. The tube-mill discharge is returned to the classifier by a bucket-elevator and the product kept in the circuit until sufficiently fine to pass off in the slime overflow.

Air Lifts Supersede Centrifugal Pumps

From the Dorr classifier the pulp continues to a 20 ft. by 10 ft. Dorr thickener. The slime product from the classifier contains 6 parts solution and 1 of solid, and is thickened to a ratio of 2 to 1. The centrifugal pump at first employed to elevate pulp from the thickener to the agitating tanks has been replaced with an air-lift. This was done because of the excessive wear on the pump by the hard and gritty slime. Six hp. is required for operation, and the air-lift has proven most satisfactory. The three agitating tanks are of the Pachuca type, 10 ft. by 30 ft. They are arranged in such a way that any tank can be passed and eliminated from the circuit without interfering with operations. Air is supplied at 40-lb. pressure to agitators, air-lift and filter department by an Ingersoll-Rand 8 in. by 10 in. standard air compressor.

Lead acetate was formerly added to the solution in agitators and stock tanks at the rate of 30 to 40 lb. per working day; but experiments proving that 24 lb. of commercial litharge produced as favorable results, the latter was used instead, resulting in a marked saving in costs. The litharge is added to the tube-mill and agitators in equal amounts. After agitation the pulp goes to a second Dorr 20 ft. by 10 ft. thickener, the overflow from which proceeds to the collecting tank, and thence is pumped to the clarifying and precipitating department. The underflow passes to the filter. As the ore milled averages $20 per ton, the pregnant solution is high-grade. In order to reduce the gold content of the pulp passing to the filter, the agitated pulp flowing to No. 2 thickener is diluted with the overflow from No. 1 thickener and barren solution by mixing the $3 per ton solution from No. 1 thickener with the $8 product of the agitators, and by the addition of considerable barren solution from the stock tanks. In this way the gold content of pulp passing to the Oliver filter is reduced from $8 to $2 per ton. The filtrate is combined with the overflow from

No. 2 thickener, and the clarified solution is precipitated in Merrill presses by the customary zinc-dust method. The mill extraction has never fallen below 95% in any month, and at times has exceeded 97%. The daily capacity of the old mill using light stamps, was 66 tons. With the 1250-lb. stamps the capacity has been increased to 100 tons.

Improvements in Concentration

The use of canvas tables in concentration is still favored by a majority of California millmen, but progress in this department of milling is also being recorded. The original California concentrator consisted of a wooden frame covered with bullock hides, supported by stringers to give fair rigidity and strength. Later on heavy carpet and specially woven blankets were employed to arrest the gold escaping the amalgamating plates. The employment of canvas later came into favor, and this material is still largely employed in California concentration. Two distinct types of tables are used: the long and narrow, and the broad and short. The latter is generally preferred, because of the ease with which it is operated, but both types have many advocates. The table that has found greatest favor is about 12 ft. wide by 13 ft. long, provided with short lengths of hose at frequent intervals to facilitate easy washing. The tables are built with an inclination of 1 to 1½ in. per ft., and are constructed of 2 by 8 in. stringers with redwood or pine flooring. No. 7 or No. 8 canvas is generally used. At the larger mills the tables are arranged in a double bank.

In early California practice the pulp from the batteries passed direct to the canvas or blanket concentrator, but the method now favored is the treatment of the pulp on Gates or Frue vanners before passing to the tables. In this way a higher concentration is secured. In the Kennedy mill, one of the largest in California, 40 Frue vanners and 56 canvas tables are employed in concentration.

Latest Type of Canvas Table

The tendency in California concentrating is to secure a clean product at a reduced labor cost, and one of the advantages claimed for the Darrow-Hambric type of table is that it meets this requirement. This table is the latest type of the California canvas concentrator and embraces several features of interest. In place of the usual canvas covering, asphaltic felt or boards coated with asphalt paint are employed to collect the gold. The tendency in concentration is toward the employment of a finer collecting surface, as shown by the gradual change from rough blankets to the smooth canvas surface. The use of asphaltic felt and asphalt-painted and sand-coated lumber in the Darrow-Hambric machine is a further step toward the fulfilment of the smooth surface requirement by California millmen. In the case of the painted and sand-coated tables the loads are less than when employing canvas or felt, but the product is said to be cleaner and the gold extraction higher. In combination with the asphalt-felt tables their efficiency is stated to be particularly good, and their use in mills along the Mother Lode is finding much favor.

As shown in Fig. 1, the Darrow-Hambric tables consist of a circular supporting steel frame 20 ft. in diameter, divided into 14 sections, 10 decks high, with 140 distributing boards and an equal number of plane, rectangular concentrating surfaces or trays. Only four of the latter are shown in Fig. 1, extending in front of the distributing boards. Each tray is 3 ft. by 4 ft., giving a total concentrating area of 1680 sq. ft. The surface of the trays is either painted and coated with sand, or covered with fabric or asphalted felt. These specifications can be modified to give a table 28 ft. in diameter, divided into 21 or 24 sections 6 to 10 decks high, with total concentrating areas of 1512 to 2880 sq. ft.

The circular supporting frame is mounted on a central vertical shaft, with arms radiating to the circumference, and is revolved by a rope drive. A complete revolution is made in from 15 to 20 minutes, according to the desire of the operator. The cycle of treatment during one revolution of the table consists in (1) distributing the slime pulp to the different trays, forming a thin layer over its entire surface, (2) gently washing the loaded trays with water to remove the light sand, and (3) discharging the concentrate into a collecting launder by means of a strong spray of water from a perforated pipe. The device thus becomes, in effect, a form of continuous and automatic canvas plant.

The free-milling character of most California gold-bearing quartz has contributed to the conservatism prevailing among the millmen of the State, as the ease with which an excellent extraction has been secured by stamp-crushing, amalgamation and concentration created a prejudice in many districts against the employment of more advanced methods. While it has been recognized for years that the tailings from many of the mills carried an appreciable gold content, many operators doubted the ability of the cyanide process or any other method to make a sufficiently large saving to justify costs attending installation and operation of necessary equipment. But the success attending the employment of the cyanide process by the North Star, Empire, Black Oak and other progressive companies has convinced even the most skeptical operators that the method will increase their earnings and many of the companies that have clung to oldtime practices for two generations are discarding their time-honored methods for the improved practice of a newer and better age.

Pitot Tubes for Gas Measurement

In view of the increasing importance of the exact measurement of the flow of gases in the chemical and metallurgical industries, an elaborate paper on this subject, by Mr. **W. C Rowse,** published in the September issue of the *Journal of the American Society of Mechanical Engineers,* is of considerable interest.

The pitot tube as a means of measuring gases has the advantage of being correct in principle, inexpensive, portable, and is, in general, easily applied. But the accuracy of the different forms of pitot tubes has long been questioned, the maker of each form supposing that his tube is correct, while as a matter of fact no two forms of tube agree.

The purpose of Mr. Rowse's experiments, which were made
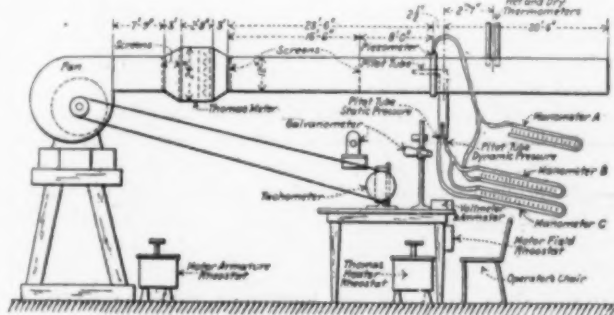
FIG. 1.—ARRANGEMENT OF TESTS

in the laboratories of the University of Wisconsin, was, first, to investigate the reliability of the pitot tube as a means of measuring gases, and second, to ascertain which forms of the pitot tube now in common use give correct and which incorrect results in the measurement of gases.

The method of procedure was to force air through a pipe in which the pitot tube to be tested was inserted, together with a standard gas meter. As standard, a Thomas electric gas meter (described in some detail in our Vol. IX, page 162, March, 1911) was chosen.

The apparatus used in the experiments on pitot tubes is shown diagrammatically in Fig. 1.

A No. 2½ Sirocco fan driven by a 7½-hp direct-current shunt-wound motor forced air through the Thomas meter into a galvanized iron pipe, 12 in. in diameter, in which the pitot tube to be tested was inserted.

Variable resistances were placed in series with both the field and the armature of the motor, thus making possible a wide variation in speed. A stationary tachometer belted to the fan

was so located that it could be observed at all times by the experimenter at the pitot tube. The field rheostat was brought within reach of the operator so that the fan could be maintained at any desired constant speed during a test.

Screens were inserted at the points shown in Fig. 1 in order to break up eddies and whirls and to have the air flow as nearly parallel as possible at the point where the pitot tube readings were taken. All joints between the Thomas meter and the pitot tube were made thoroughly air-tight to prevent leakage. The barrel of the Thomas meter was lagged by three thicknesses of heavy blanket in order to prevent any possibility of error due to radiation to or from the meter casing.

The experimenter was stationed directly under the pitot tube and all readings were taken at this point. A mercury barometer, hung on the adjacent wall, gave the atmospheric pressure, and a manometer inclined at a 10 to 1 slope made it possible to determine accurately the static pressure in the pipe above atmosphere. The dry-bulb thermometer indicated the temperature of the air flowing in the pipe and together with the wet-bulb thermometer gave readings from which the humidity could be determined.

The pitot tube is a well-known measuring instrument and needs only a brief description. It consists essentially of two parts, a dynamic tube pointing upstream, which converts the sum of the pressure energy and the velocity energy into a head which may be measured, and a means of determining the pressure head (or static pressure) alone. The difference between the dynamic head and the static pressure head is the velocity head h in the fundamental formula for the flow of fluids

$$v = \sqrt{2gh}$$

where

     v = velocity in ft. per second,

     g = 32.2 ft. per second per second,

     h = mean velocity head in ft. of the fluid flowing.

It has been satisfactorily proved and accepted that the dynamic tube gives the correct pressure if the tube points parallel to the current. But it is a very difficult matter to obtain the correct static pressure on account of secondary velocity effects. Therefore the study of the accuracy of the pitot tube resolves itself into a correct study of the correct method of obtaining the static pressure at the given cross-section where the tube is inserted.

Each pitot tube tested had as a part of the tube a means of determining the static pressure, and readings of the velocity head were obtained by using this pitot-tube static pressure. Simultaneous readings of the velocity head were obtained by using a piezometer ring for the static pressure together with the dynamic tube of the pitot tube under test. This is further illustrated by reference to Fig. 1. Manometer B gives the velocity head by using the piezometer static pressure, and manometer C gives the velocity head by using the pitot-tube static pressure. In both cases the same dynamic tube pressure is used. This piezometer, even if it were possible to be in error, would always indicate the same pressure under the same conditions irrespective of the tube under test and thus it afforded an additional means of comparison independent of the Thomas meter.

The piezometer is shown in Fig. 1 and is simply an air-tight annular space about the pipe, connected with the interior of the pipe by six small holes 0.04 in. in diameter.

The velocity of a gas flowing through a pipe is much greater at the center than near the walls of the pipe. In addition, it was apparent from the tests that the gas flows through the pipe with a wave or spiral motion even when many screens are inserted to straighten out the stream lines. Therefore, it was necessary to take a large number of readings across two diameters of the pipe. The total area of the pipe was divided into five concentric annular areas and four readings of the velocity head were obtained in each test at the center of each annular area, thus giving 20 readings from which the mean velocity head could be calculated. Since the velocity varies as the square root of the velocity head it was necessary to average

the square roots of each of the 20 readings, and the square of this average represented the mean velocity head. Readings were also taken at the center of the pipe in order to determine if any definite relation existed between the mean velocity head and the velocity head at the center of the pipe.

The pitot tube under test was held in place by means of a brass bushing or holder which could be fastened by screws to brass facings soldered to the outside of the galvanized air pipe. The facings were 90 deg. apart, thus permitting readings to be taken on both the horizontal and vertical diameters.

The principal characteristics of the various pitot tubes tested are indicated in the table given in the summary at the end of this article.

The author proceeds to describe in detail the gages for measuring the velocity heads, and then gives an account of the procedure in making the experiments and calculations. The results of the tests are given in a long series of tables and diagrams.

The principal results are summed up in table 1, in which the terms M, N, Q, U, Z have the meaning explained by the following formulas:

$$C_1 = MC_2 \text{ or } M = \frac{C_1}{C_2}$$

$$C_1 = NC_3 \text{ or } N = \frac{C_1}{C_3}$$

$$C_3 = QC_2 \text{ or } Q = \frac{C_3}{C_2}$$

$$V_1 = \sqrt{2gh_1} = \sqrt{2gUh_3} \text{ or } U = \frac{h_1}{h_3}$$

$$V_2 = \sqrt{2gh_2} = \sqrt{2gZh_4} \text{ or } Z = \frac{h_2}{h_4}$$

where

   C_1 = cu. ft. of air per minute by Thomas meter

   C_2 = cu. ft. of air per minute by the pitot tube using the pitot static pressure

   C_3 = cu. ft. of air per minute by pitot dynamic tube and the piezometer static pressure

   V_1 and V_2 = velocity of the air flowing in ft. per sec.

   h_1 = mean velocity head in ft. of air flowing, obtained by the pitot tube using the pitot static pressure

   h_2 = velocity head in ft. of air at the center of the pipe obtained in the same manner as h_1

   h_3 = mean velocity head in ft. of air flowing, obtained by the pitot dynamic tube and the piezometer static pressure

   h_4 = velocity head in ft. of air at the center of the pipe, obtained in the same manner as h_2.

M and N are, therefore, coefficients by which the actual results obtained by the pitot tube must be multiplied to obtain the correct flow of gas. Q gives the coefficient by which the results from the pitot tube alone must be multiplied to obtain the same discharge as that shown by the pitot dynamic tube and the piezometer. U and Z state the relations between the velocity head at the center of the pipe and the mean velocity head as determined by the two methods used in the experiments.

(The significance of the figures in table 1 will be clear from the above definitions. For instance, if we want to know what type of pitot tube used alone for getting the static pressure gives the highest accuracy, we have to look up the figures for Q which represent the coefficient by which the results from the pitot tube alone must be multiplied to obtain the same discharge as that shown by the pitot dynamic tube and the piezometer. The nearer to unity the value of Q, the more exact is the pitot tube in question. From the table we see that Q is nearest unity in case of pitot tube Y, the standard tube of the American Blower Company. The value of Q in this case is 0.9992, the error, therefore, only 0.08 per cent.)
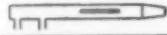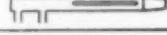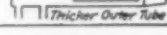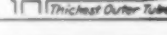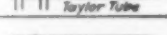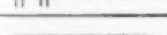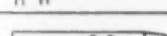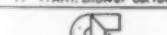
From a study of the summary, table I, Mr. Rowse draws the following general results and conclusions:

(*a*) The pitot tube as a means of measuring gases is reliable within approximately 1 per cent when the static pressure is correctly obtained and when all readings are taken with a sufficient degree of refinement; in order to obtain this degree of accuracy the pitot tube should be preceded by a length of pipe 20 to 38 times the pipe diameter in order to make the flow of gas as nearly uniform across the section of the pipe as possible.

(*b*) All the methods of obtaining the dynamic head used in these experiments, including the German Stauscheibe (*S*), give accurate results.

(*c*) The most reliable and accurate means of obtaining the static pressure is the piezometer or its equivalent, the results of 138 separate tests using the piezometer static pressure agreeing with the Thomas meter within an average of 0.33 per cent;

TABLE I

Name of Tube	M	N	Q	U	Z
A	1.0614	1.0175	1.0413	0.7696	0.7936
B	....	....	1.0579	0.8019	0.7898
C	......	....	1.0343	0.7996	0.7880
*C	1.0346	0.9952	1.0384	0.8107	0.8066
D *Thicker Outer Tube*	....	....	1.0369	0.7927	0.7942
E *Thickest Outer Tube*	....	....	1.0489	0.7885	0.7898
X *Taylor Tube*	1.0987	0.9925	1.1074	0.7606	0.7867
G	1.0076	1.0085	0.9989	0.8100	0.8164
H	1.0218	1.0152	1.0065	0.7966	0.7957
Y *Am. Blower Co. Tube*	1.0034	1.0017	0.9992	0.8002	0.7996
K	1.0069	0.9924	1.0626	0.7617	0.8115
L	1.0104	1.0032	1.0064	0.7593	0.8112
Average	....	1.0033	....	0.7884	0.7986
S	0.9861	1.0016	0.9844	0.7780	0.8228

these results show beyond any doubt that the static pressure is constant across any section of a pipe in which gas is flowing at a uniform rate.

(*d*) Of the methods of obtaining the static pressure by the pitot tube itself, the most reliable and accurate is by means of a very small hole in a perfectly smooth surface, as in pitot tube *Y*.

(*e*) The long slots for obtaining the static pressure are not reliable and give results which are in error from 3.5 to 10 per cent. The length of the slots or the thickness of the outer tube do not appear to affect the accuracy of the tube.

(*f*) The beveled tube for obtaining the static pressure as used in pitot tubes *K* and *L* is not reliable. A very slight change in the angle of bevel produces an appreciable change in the result. In taking a traverse of a pipe the sides of the pipe affect the readings. But the greatest error is produced by the 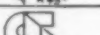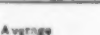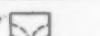uncertainty as to whether the tube is pointing directly upstream. If the tube is off 20 deg. in one direction an error of 85 per cent in the velocity head is introduced.

(*g*) The Stauscheibe gives accurate results using either the static reading from the Stauscheibe and a special formula or by using the piezometer static with the usual formula for the pitot tubes. In the first case the agreement is within 1.4 per cent and in the second within 0.16 per cent.

(*h*) It appears that an approximate relation exists between the mean velocity head of a gas flowing through the pipe and the velocity head found by placing the tube at the center of the pipe. For a 12-in. galvanized iron pipe results within 2 per cent may be expected from using the formula:

$$v = V \, 2g \times 0.80 h_c$$

where

$v =$ velocity in feet per second

$g = 32.2$ feet per second per second

$h_c =$ velocity head in in. of gasolene at the center of the pipe obtained in a correct manner.

Electric Furnaces, Their Design, Characteristics and Commercial Application.

By Woolsey McA. Johnson and George N. Sieger.

The Electric Furnace Structurally Considered.

Certain electric furnaces, as the carborundum furnace or the graphite furnace, are not strictly metallurgical structures, for they are simply built up and torn down after each run. This is a perfectly proper procedure, for the high temperature
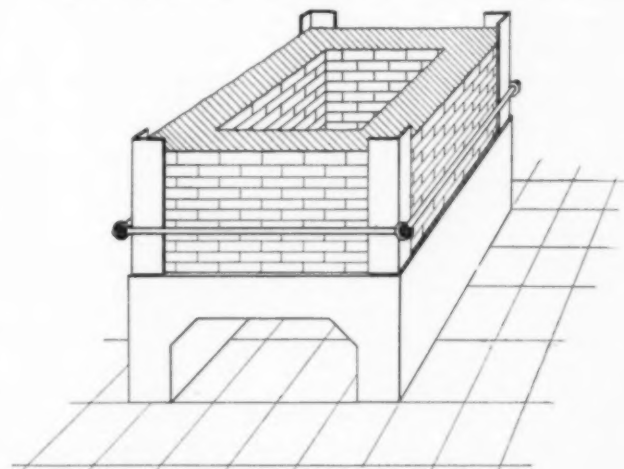
FIG. 1.—SECTIONAL VIEW OF OBLONG OR SQUARE FURNACE SHOWING SIMPLE MANNER OF TIEING. OUTSIDE COURSE IS TO BE LAID IN CEMENT MORTAR UNLESS IN METAL CASE. FURNACE BUILT ON TABLE OF REINFORCED CONCRETE

(2200°C. to 2500°C.) would make any permanent furnace an engineering impossibility at present and it would not be good business with the present handsome margin of profit to bother about the unattainable.

But certain other furnaces which have a direct competition with pyro-metallurgical furnaces must be built so that the cost for repairs and renewals is within fixed industrial limits. Such a furnace must have its two basic mechanical elements,—the refractory lining and the structural "ironing" that holds lining in place,—of a design suitable for its metallurgical needs. The refractory lining must resist the action of such hot slags and metals as it is to contain. The "iron-work" (a somewhat indefinite term used to cover a multitude of virtuous devices) holds the lining and brick work together so that it is a self-contained piece of apparatus and one that will not fall apart.

Just as in any industrial concern we have older men giving advice and acting for conservatism, and young men full of energy and tireless refractoriness, so in a metallurgical furnace we have the complementary parts of firebrick and steel each doing a different duty.

From an idealistic standpoint firebrick work is supposed to possess no mechanical strength, except resistance to crushing.

We must then consider that the bricks are bound together by the inwardly-directed force of compression, which comes originally from the tension rods of the outside framework and that structural coherence comes from friction. Practically it is possible to depart from theory, for the strength given by the mortar is sometimes great.

When it comes down to a question of facts, the design and erection of a furnace is largely a matter of practical exper-
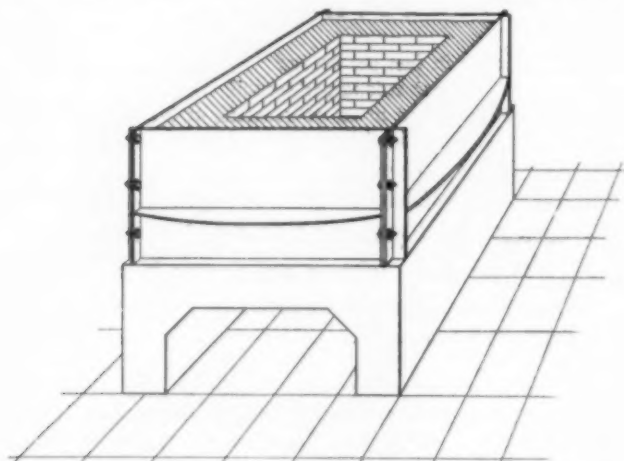
FIG. 2.—SECTION OF FURNACE BUILT OF CAST IRON PLATES ALSO ON TABLE OF A REINFORCED CONCRETE

ience and "get-there-ness." But if interpreted with engineering common-sense, theoretical considerations are of value. Indeed they are always present unconsciously in the mind of many so-called ignorant workmen and it is the wise engineer who avails himself of truth and knowledge from any source.

Undoubtedly the simplest form of "iron-work" for a furnace is a box made of sheet steel ⅛ in. to ⅜ in. thick, reinforced on the corners with riveted angle bars. See Fig. 1. This furnace can be securely tied by tie rods made in identical manner to tie rods on a square brick chimney. This form is a good one for an experimental furnace. The brick work is laid inside in dimensions of multiples of 4½ inch.

Cast-iron plates with flanges running both horizontally and
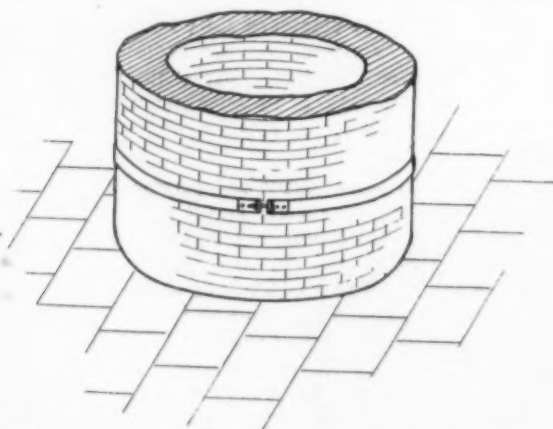
FIG. 3.—SECTIONAL VIEW OF SIMPLE "POT" FURNACE BUILT OF "RADIUS" BRICK OR OF "KEY" BRICK. OUTSIDE COURSE MUST BE LAID IN CEMENT MORTAR UNLESS STEEL SHELL IS USED

vertically makes a better job of this design often, especially if the furnace is a permanent one. See Fig. 2. This specially cast stuff costs more than sheet steel.

Cast steel plates are practically perfect, but their cost is the highest.

Electrodes are inserted in holes. Such furnaces are built of insulated bolted sections.

Cooling of the outside by water is the way when any severe duty is placed on the refractory lining. These water-jackets, spray-plates, or bosh-plates have to be held in place in a majority of cases by the inwardly-acting force of steel rods or steel hoops.

Where a round furnace is used the steel shell is made in the form of a hollow cylinder. Steel hoops with adjustable means of loosening or tightening can be used when great mechanical strength is demanded. See Fig. 3.

An oblong furnace is tied with rows of rods running in all three directions and engaging buck-stays. See Fig. 4. Buck-stays are made of cast iron, I-beams or old rails. A buck-stay is a mechanically strong piece of metal backing up the brick work and taking the outward thrust of expansion.

Brick walls laid in cement mortar or reinforced concrete walls can be used for the outer walls, provided the metallurgical duty is not severe. This makes the outer wall one-piece.

In any case we must conceive of the lining holding the contents, the outer walls holding the lining and the "iron-work"
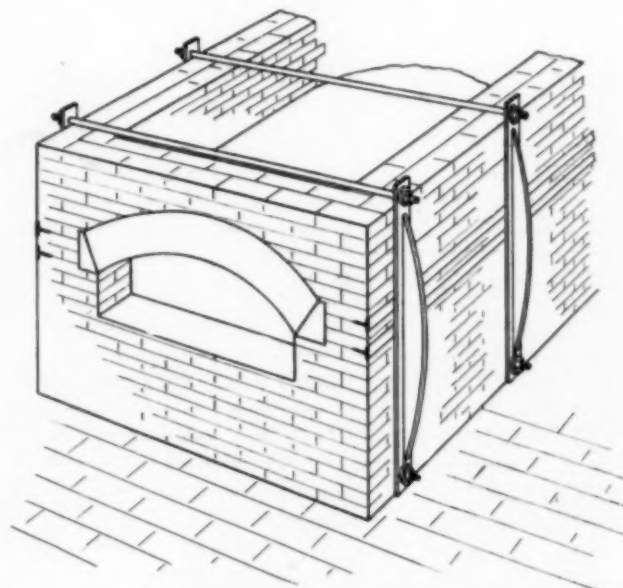
FIG. 4.—FURNACE WITH CAST-IRON BUCKSTAYS AND TIE-RODS RUNNING AT RIGHT ANGLES TO TAKE THRUST OF ARCH

holding the outer walls. These things must be grasped by the mind at the same time. The relative duty and the association of different functions of the parts operate in good design for a common end. For instance, the ultimate force is the tension on the tie rods, coming from the turning of the nuts or twisting the turn-buckles. Opposed to this is the expansion of the firebrick on heating. These forces must be in equilibrium. Otherwise distortion or possibly rupture ensues.

Proper allowance for this fact must be made in design and the furnace must be watched on heating up and tie rods slackened. Probably the simplest way to compensate such forces is by the use of spiral steel compression springs acting on ends or in middle of tension rods. In such a manner the force is progressively compensated and without trouble and without care on the part of furnace-man and engineer. Were it not for increased expense, the authors would never design any furnace without use of spiral compression springs. Accordingly, where question of expansion is serious, springs on rods can be used. Fig. 5 shows one manner of using compression springs.

Tie rods are usually made by welding boughten "bolt-ends" to steel stock, but the threads can be cut if convenient. Turn-buckles and clevis can be used but do not seem to be as serviceable for all 'round work as nuts and bolts. In welding a bolt-end to a tie-rod allowance must be made for the fact that the cut of thread has diminished the effective area of bolt-end

by just so much as twice the distance from the outer circumference to the root of thread. To use square ½-in. rods to a ¾-in. bolt-end, square ¾-in. rods to 1-in. bolt-ends, and so forth, is a practical rule. In spite of proper personal pride of the blacksmith, the weld has only the strength of from 40% to 80% of original stock. The weld should be a "scarf weld" near the bolt-end made so as to thicken up the stock as much as possible.

The preceding description can be summed up as follows:

(1) There should be a lining that is refractory and this lining must be held in place by compression.

(2) There should be a shell or outer wall that distributes this compressive force uniformly to the lining.

(3) The "iron-work" should receive this inwardly acting force from the strain of tension of steel.

(4) All of the above must be so proportioned that each does its proper work.

When the above is achieved, the furnace is perfect.

Electro-Metallurgical Idiosyncrasies

In general, an electric furnace for conditions below 1600°C. resembles in its construction ordinary pyro-metallurgical fur-
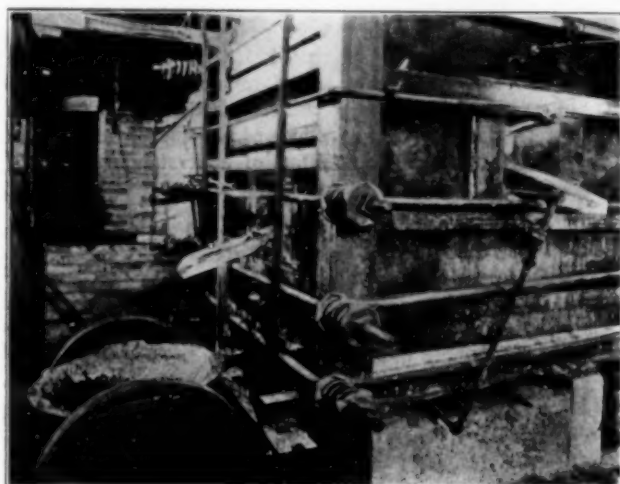
FIG. 5.—ELECTRIC FURNACE CONSTRUCTION SHOWING USE OF COMPRESSION SPRINGS

naces. There are three differences, however, one electro-metallurgical, one electrical and one magnetic in cause.

If at any time the furnace does not functionize, or if too much electrical energy is applied, the temperature of the contents will rise in short period to an extraordinary degree, before the radiation or smelting will cool it down. This is liable to happen at any time. Accordingly the lining must be able to stand self-abuse and extraordinary hard work.

So also with electric current; the tie rods and steel are conductors and if accidentally in contact with both sides of power line, a bad short circuit ensues. By inserting in convenient places ¼ in. strips of John B. Pratt Co.'s "Vulcabeston" with bearing plates of ¼ in. bar iron this cannot happen. This is a wise precaution although the firebrick alone is generally enough of an insulator.

Most electric furnaces employ alternating current. The "iron-work," therefore, must be broken where possible by air gaps, by brick or by "Vulcabeston," with structural strength still preserved. This point can be seen in the design shown in Fig. 5. Otherwise, the inductive drop due to voltage absorbed for no other purpose but to magnetize the "iron work" with each alteration becomes commercially important and power factor especially in large units drops to low figure.

Refractories

The subject of refractories is a large one and also a peculiar one. The backward state of this art can be well seen by the fact that the same substance, aluminium silicate, is used for firebrick to keep in heat and as a heat insulator, and for retorts, muffles, and crucibles to bring in heat, which should be heat conductors. (Cf W. McA. Johnson, *Electrochem. & Met. Industry*, Vol. III, page 214 and Vol. IV, page 6.)

But at present the great amount of work which is being done in metallurgical and chemical engineering circles on the subject of refractories is sure to bring eventually discoveries of great commercial worth. If some practical scientist should invent and perfect a refractory, inert to usual metallurgical substances as slags at a temperature up to 1700° C. and a fair non-conductor of heat and electricity at that temperature, he would be performing an invaluable service to the profession. Furthermore, he might make a fortune.

The general kind of refractory is made of silicate of alumina and goes by the name of common firebrick. This is manufactured of two physically different forms of material, (1) plastic or hot clay and (2) "grog," i.e., coarse particles of crushed burnt fireclay. The former material gives firebrick strength, the latter gives them cohesive powers.

Firebrick vary in refractoriness depending on impurities in clay on manufacture and physical distribution of impurities. In general, it can be said that any substance that tends to make a blast furnace slag more liquid, as soda, iron oxide, or lime, diminishes the refractoriness of firebrick. Good firebrick will stand a heat of 1475°C. to 1525°C., while firebrick are made that will stand 1600°C.

Firebrick at any temperature will not long stand hot liquid slag,—especially in an electric furnace, unless they are cooled in some manner. In the latter case they simply are eaten away until the cooling is such that a protective layer of congealed slag stops further corrosion.

Firebrick are made in many shapes and sizes. Ordinary stock shapes are as follows:

Straight	9″ x 4½″ x 2½″
Soap	9″ x 2¼″ x 2½″
No. 1 Split................	9″ x 4½″ x 1¼″
No. 2 ″	9″ x 4½″ x 2″
Large Straight	9″ x 6¾″ x 2½″
Plate	12″ x 12″ x 2″
Slab	23″ x 5″ x 3″
Slab	28″ x 8″ x 5″
No. 1 Arch................	9″ x 4½″ x 2½″ to 2⅛″
No. 2 "	9″ x 4½″ x 2½″ " 1⅜″
No. 3 "	9″ x 4½″ x 2½″ " 1⅛″
"Bung" "	9″ x 4½″ x 2½″ " 2⅜″
No. 1 Key................	9″ x 4½″ to 4″ x 2½″
No. 2 "	9″ x 4½″ to 3½″ x 2½″
No. 3 "	9″ x 4½″ to 3″ x 2½″
No. 4 "	9″ x 4½″ to 2¼″ x 2½″
No. 1 Wedge...............	9″ x 4½″ x 2½″ to 1⅞″
No. 2 "	9″ x 4½″ x 2½″ to 1½″
No. 3 "	9″ x 4½″ x 3″ to 2″

Radius brick 9″ x 6 9/16″ x 4½″ to 2½″ are especially convenient at times as well as big blocks 18″ x 12″ x 8″, and "skew backs." Tiles, slabs and plates are made in a variety of other sizes.

With an intelligent mason, furnished with plenty of sharp "skutches" and chisels, almost any furnace can be built of above shapes. Not unoccasionally, however, it is business to have made special shapes, as for instance for a "flat" arch, or for ring around charging hole. But by use of beveled edges and by applying plenty of compressive force many things can be done, if ingenuity and persistence are at hand.

There are three other kinds of refractories that are much more expensive than firebrick, but better for use where high heats are used and special conditions are to be met. These are magnesia brick, chrome brick and silica brick, made respectively of basic, neutral, and acid material. All these brick have high coefficients of expansion on heating and expansion must be liberally allowed for. See Fig. 6.

Magnesia brick are used with a basic slag, for instance, in

modern copper converting or in basic open hearth bottoms. They can be laid in fine dust, milled from old brick mixed with hot tar, linseed oil or water-glass. They are also laid dry. A bottom can be made of old magnesia brick, dust, and water-glass, just as concrete is laid, and if dried slowly
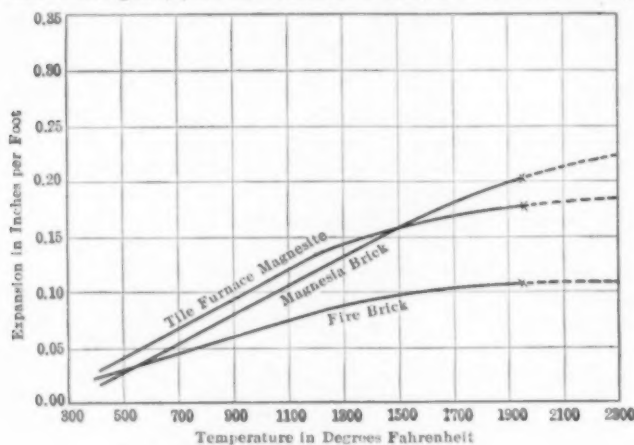

FIG. 6.—TEST OF EXPANSION OF REFRACTORIES

and thoroughly baked it will hold metal fairly well. The water-glass, of course, diminishes the refractoriness of the work, but adds to other properties, such as coherence.

Chrome brick are used at times as an equivalent of magnesia brick. They make an inert insert between courses of magnesia brick and silica brick which might flux together, and also are suitable around tap hole of furnace. Both chrome and magnesia brick conduct heat several (2 to 4) times as well as ordinary firebrick.

Silica brick are laid for arches which are subjected to considerable heat, e.g., in Heroult electric steel refining furnace. Silica brick are made out of special silicious material, e.g., ground sandstone mixed with a little lime "putty" as a bond, and then burned. They are laid in mortar of same material out of which it is made. All three kinds are only made in few stock sizes. They are all apt to be warped to some extent in burning, and are not true to shape or size at all. All these as well as common firebrick are porous to a considerable degree.

Other kinds of brick can be used but are less common, e.g., "bauxite" and "alundum" brick, in special cases to meet special conditions. Of course, in an electric furnace, with its reducing atmosphere and in an electric furnace plant where there are always plenty of stub ends of electrodes, carbon brick are fine. But sooner or later they burn out by accidental or incidental oxidation. They are all right for experimental work or where it is commercial to run a furnace a short time and then rebuild it. They can be laid up in a mixture of tar and carbon dust.

It is well to have several barrels of pugged firebrick mixture bought from a firebrick manufacturer on hand in any small plant. This can be rammed into the interstices when necessary,—such as when changing from "headers" to "rowlock" or

FIG. 7.—SIMPLE ARCH SHOWING.. "RISE," "SPAN" AND "SKEWBACKS"

"stretchers" the courses do not work even. "Asbestos-retort" cement makes a good filling where not exposed to temperature above 1200 deg. C. Johns-Manville or American seal are good brands.

Electrically sintered magnesite with a special bond, which is furnished the trade by the Norton Co. is of value in special places in furnaces with basic lining. It should be tamped in warm with red-hot steel tampers.

All brick work should be laid tight, brick to brick, with expansion joints where needed and where designed. Where the firebrick are subjected to severe duty, they should be dipped in thin "fire-clay soup" and tapped with a mason's hammer into place." *The mortar should be same stuff as brick*, very fine and mixed thin with water or other liquid. In certain cases, the brick can be laid with thicker mortar and by use of a trowel. Not unseldom a little cement can be mixed with fire
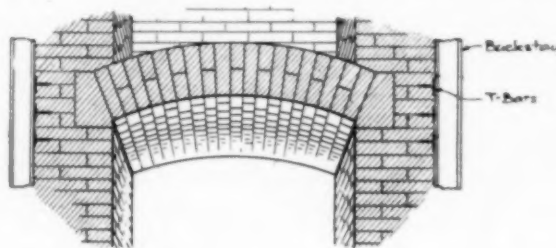
FIG. 8.—SHOWING ARCH AND MANNER OF BREAKING JOINTS IN AN ARCH. ALSO THE BACKING OF THE "SKEWS" WITH T-BARS HELD IN PLACE BY BUCKSTAYS

clay, especially where brickwork is exposed to weather or where mechanical strength is needed. But this is a matter of judgment, for cement diminishes refractoriness.

But, when all things are considered, the use of firebrick and other refractories so as to produce results cheaply and efficiently is an art, not a science,—an art of understanding conditions and ways of making things practical, not a science or an academic theory.

Laying an Arch

The laying of an arch is a matter that requires care and conscience. The first thing to do is to figure out the "sweep." The "sweep" is rise in inches per running horizontal foot of arch. This changes in a circular arch but as most metallurgical arches are built with practically constant curvature, the term sweep can be used all right. The "span" is distance between lower points of "skew-backs." The "rise" or "raise" is distance from bottom of "key-brick" to line running from lowest point of skew-back. See Fig. 7.

The "sweep" of an arch has ordinarily a minimum safe value of 1½" to 12". But the work must be carefully done and on intermittent service of furnace an arch with sweep of 1½" to foot or 4½" "rise" to 72" "span" would not stand unless made of key or wedge brick, and unless the "skew-backs" were securely tied in. A sweep of 2" to one foot is a good figure to keep in one's head.

Arches, as everyone knows, are laid on wooden forms, which are burned out on drying furnace. The important part of an arch is the "skew-back." See Fig. 8. These should be of large blocks and slightly bigger on skew-face than thickness of arch. The skew face is flat to receive the first brick in perfect contact. *Skewbacks must be backed up on rear with first-class brickwork.* The final backing is an angle bar or a tee bar set in the brickwork and this should be held in place perfectly by the "iron work." It is the first rule of arch construction to "look after your 'skew-backs,'" and to see that they cannot be displaced any fraction of an inch.

Every surface of bricks in an arch must be in good mechanical fit with surface touching, since there can be no sliding along planes of contact. For many places where "span" is short, big blocks can be used to replace the arch. For a short span a single block supported at both ends on walls, suffices. By holding these down securely it is possible to span with two of these set "cantilever" fashion a full 36". See Fig. 9. In other places these can be cut in form of "jack arch" or "Dutch arch," to use another colloquial term.

An arch is necessarily laid tight and with "joints broken" as in all brickwork and with a smooth fit on all surfaces. See Fig. 10. The final key-bricks are driven home with a hammer. The blow should be received on a wood, such as a short end

of a 2" x 4" and never on the brick directly. Arches are laid with especial care when they have heat on both sides of them.

It can be remarked that any big block such as one for a "skew-back" or a "Dutch arch," had best be cut on a bed of sand. The bed of sand absorbs the jar of the cutting tools and stops the generation of fissures and possible ultimate cracking of the block.

As brick are laid wet, the furnace must be dried out. This drying should be slow with a gradual raise of the heat. Twenty-four hours drying for each 4½" or for each course of brick is a safe rule. Thus a furnace with 9" wall would take 48 hours to dry, and with an 18" wall, 96 hours. As the brick
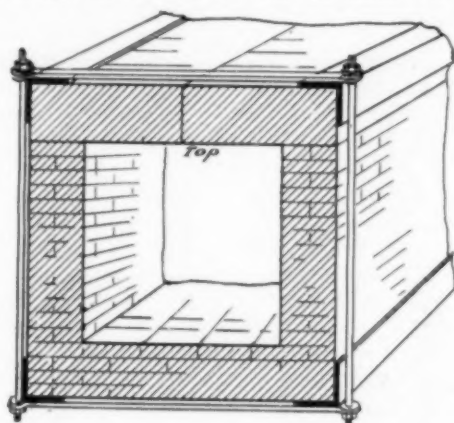

FIG. 9.—SHOWING WAY OF COVERING OVER A FLUE ON A SMALL FURNACE WITHOUT USE OF AN ARCH. THIS IS PRACTICAL TO SPANS AS LARGE AS 30" TO 36". THIS FORM OF CONSTRUCTION IS PARTICULARLY APPLICABLE WHERE A FLAT COVERING IS ADVANTAGEOUS

retain moisture and are decidedly hygroscopic a great heat applied suddenly would generate steam so fast as to cause trouble and a wood fire is used, particularly at first. Afterward a coke fire or an electrically heated coke resistance can be employed, but this is a little risky.

At the time the furnace is being heated up the tie rods should be adjusted, so as to meet properly the increasing strain.* Care is taken in bringing a furnace up to working temperature and a policy of conservatism is the only one to be employed. The injunction to "play it safe" is about as good advice as can be given.

Water Cooling

We have learned in the case of slag tap-holes, electrode ports, and electrode connectors, that the way to reduce the cost of repairs and renewals to a minimum was to use where we could, water-cooled metal instead of a refractory. For as long as the water was circulated freely the metal could not be destroyed and a permanent piece of apparatus was made.

Now although electric heat is expensive and heat insulation is desirable, provided it is attainable, it is not good business to try to save money in the power item and waste twice as much money in the repair and renewals item. For many purposes water-cooling of an electric furnace in a manner similar to that used where locomotive fire-box, and iron, copper or lead blast-furnace is water-cooled is a proper design.

A characteristic of electric furnaces is in many types an excessive local heating in places and at times. This produces bad results and if the electric furnace is to have any extended commercial application beyond its present restricted limits, troubles arising from the afore-mentioned causes must be eliminated or held under control.

There is, all things considered, no better way or at least no simpler way to attain permanency of furnace shape than by water-cooling. While we have in this connection the primal disadvantage of electrothermanism as against its competitors of high-cost of the heat unit, still we have at disposal the great primal advantage of convenience of use and application of

*Peters.

electrically generated heat, when this use and this application is understood. This will be seen in the following reasoning.

The thermal efficiency of electric furnaces is always high because of direct application of energy without use of ponderable matter. In carbon-heated furnaces the waste gases are a source of loss of thermal energy even when recuperators and regenerators are employed. In electric furnaces, the heating agent is the ether, or to use the common-sense term of wise old Benjamin Franklin, the "electric fluid." This generates heat directly in an imponderable form and leaves all its energy in an easily available commercial form. Moreover, the rate of smelting by electrical means can be made high. If ratio of calories (or B. T. U.s) to cubic foot of working space per hour is higher other things being equal, the proportion of heat lost in radiation, conduction, etc., is reduced. Consequently, the thermal efficiency is higher as "smelting rate" is increased and water-cooling entails only a small percentage of heat loss. Briefly expressed, a lot of work is done in a little space.

Just here is where the electric furnace has an unsuspected thermal advantage over its competitors, for the "smelting rate" can be increased to higher values than in case of "carbon-heated" furnaces. For instance, experimental furnaces of the Continuous Zinc Furnace Company have been operated 300 lbs. of ore charged per cubic foot of laboratory space per day whereas zinc furnaces fired by gas operate in certain cases at 5 lb. of ore charged per cubic foot of laboratory space per 24 hours. Such a state of affairs puts a new light on the competition of electricity and carbon for heating furnaces. And we find that water-cooling does not possess great terrors for the designs of electric furnaces, if at the time the true principles are understood, but rather that water-cooling instills a wise and moderate respect and liking for the great service it can effect in the way of reducing cost of repairs, and increasing length of campaign.

A peculiar fact is disclosed by a study of water-cooling. The thermal conductivity of all substances increases greatly with rise of temperature. Accordingly if we have an outside
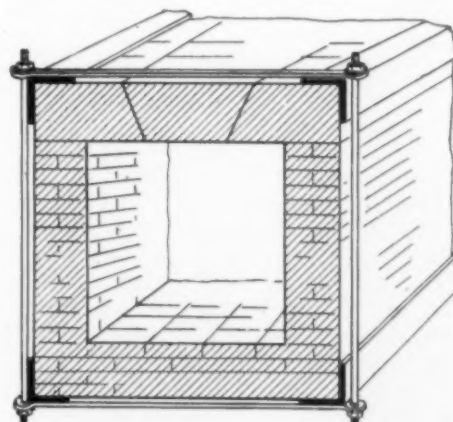
FIG. 10.—SHOWING MANNER OF LAYING A "DUTCH ARCH," SIMPLE AND CHEAP FOR SPANS UP TO 30" TO 40" OR EVEN LARGER. THIS FORM OF CONSTRUCTION IS PARTICULARLY GOOD WHERE FLAT COVER OF SOME SIZE IS DESIRED

temperature of 250 deg. C. in one case and outside temperature of 60 deg. C. in the case of water-cooled, we have a much less resistance to flow of heat in the second case. So, a thin water-cooled shell can equal as a heat-insulator a thick brick wall. It can be conceived that the "*flow of water freezes the walls of the furnace and so keeps heat inside.*"

Water-cooling can be applied to electric furnaces in any of the ways known in ordinary metallurgical practice.

These are as follows:

(1) Cast-iron water jackets.

(2) Pressed steel water-jackets with joints and stay-bolts welded by oxy-acetylene flame.

(3) Internal bronze-cooling plates same as used in back of iron-blast furnace, where a thick structural stony wall is desired.

(4) Spray-plates such as used on iron-blast furnaces. These are cheap and simple. The spray should be under a head not to exceed 10 feet and the plates should be smooth. Spray-plates are "sloppy" even when well designed, but they are the most efficient and most practical of all devices in all other respects.

In the three first-mentioned cases, care should be paid to see that no steam pockets are formed or that no sediment is deposited. By having *water enter at bottom and come out at top* and by having baffle plates to secure good circulation these troubles are obviated. In all cases the cooling metal surface is held mechanically firm to lining.

In considering case of water-cooling versus refractory walls it is well to hold in mind the nature of work to be done. If a slow "soaking" heat is the kind that work requires, design your furnace with no water-cooling. If a rapid transfer of heat is required, design your furnace with adequate cooling devices.

Or if one part of the furnace needs a "soaking" heat and the other a "rushing" heat, combine two forms of design in a composite manner.

The difference in extreme cases is deep-seated and a rational regard for this fundamental is an essential in making a good design of a commercial electric furnace.

Heat Insulation of Furnaces

We have just seen that such furnaces as are operated with a slow transfer of heat from its source to the point of absorption or of the "soaking-heat type" are not suited for water-cooling. These furnaces are usually resistance furnaces of the Cowles type. For instance, in the several forms of annealing furnaces now on the market it would be unwise to attempt to water-cool, especially as they are built in small sizes and thermal efficiency is diminished by such a procedure. In the case of small units water-cooling proves to be an undesirable complication.

In these cases the resistors are some form of carbon or of inert metal wire. The sides can be of some form of carbon with less electrical conductivity as charcoal. This forms an effective heat insulator and one resistant to fusion. But of course, if any air should touch it, total oxidation would quickly follow. Carborundum or siloxicon are other infusible substances that are used for wall next to resistor.

The study of the heat gradient will allow a use of several refractories with different properties as the heat diminishes in intensity. Magnesia brick can be used up to a temperature of 1700° C. or a pure electrically sintered magnesia, such as is made by the Norton Co., up to 2000° C. Likewise, brick made of carborundum base such as were lately put on the market by the Carborundum Co., and "alundum" brick as offered by the Norton Co., have special uses. Carbon brick are perfect as long as oxygen with any free energy is absent. Aluminum Nitride also has possibilities for refractory linings.

All these special and novel forms of refractories have their uses but can only be used where practical trial shows them to meet the needs. Some of them are too expensive for ordinary purposes. But where duty is hard, expensive brick makes for cheaper final result. It is merely a platitude to say that the choice of brick is a balancing of first cost against cost of repairs in each individual case.

For the outer layer fire-brick, red-brick, or reinforced concrete will suffice. In building a furnace of the "soaking heat" type, effective heat insulation can be gained by the use of air spaces between different courses of brick, or by separating the courses as "stretcher" courses with no "header" courses.

Mineral wool or "kiesel guhr" on the outside either plastered on or packed in a shell of asbestos board or sheet steel will keep in the heat as long as the temperature is below 700° C. Asbestos or magnesia packing such as is furnished by the Johns-Manville Co. is another convenient form.

All these varied forms of refractories have varied uses and

applications depending on the nature of the work and on the special scientific, practical, and commercial conditions that are to be fulfilled. The commercial conditions are the weighty ones, for no matter how scientifically perfect an electric furnace is and no matter how well the engineering and practical part is, unless an electric furnace is a commercial success, it is a miscarriage. Applied science is a business and the engineer must understand the principles of business and economics to a greater extent than was once thought requisite.[*]

Specific Volume and Constitution of Alloys

A paper on this subject was presented by Dr. **W. M. Guertler** at the recent meeting of the (British) Institute of Metals in Ghent, Belgium.

Dr. Guertler's paper is of a theoretical character and follows up a previous communication of his to the Institute of Metals in which he discussed the connection between the electric conductivity of alloys and their constitution.

Diagrams are given to demonstrate the dependence of the volume of alloys on concentration and temperature and explanations are given of the influence of mechanical treatment on the volume. The latter effect is generally two-fold where a normal alloy is hammered or rolled, (1) small hollows, pores, etc., closing up and the process ceasing when all these hollows have closed up; (2) where the individual crystal grains of the aggregate are broken up the grain becomes finer and this breaking up never ceases as long as mechanical work continues. The co-operation of these two factors causes the specific volume first to decrease, then to attain a minimum and again to increase as soon as the first factor is removed by the closing up of all the cavities. This explains Wertheim's discovery that the volume of metals and alloys can be increased by intense mechanical treatment. Figures are given to show the combination or the process of crystallization with that of transformation. These figures also represent and give a general idea of the "volume" surfaces of alloys.

Arsenical Copper

In a recent paper before the (British) Institute of Metals Mr. **F. Johnson** discussed a method of improving the quality of arsenical copper.

In this paper the author records the results of an investigation of the properties of specially alloyed arsenical copper with a view to proving its suitability for use as locomotive stay-rods, wire for rivet manufacture and any material required to have specially high malleability, ductility and toughness combined with tensile strength and resistance to reducing-gases at high temperatures.

An improvement in quality in these respects has been obtained by adding silicon and iron to the copper in various small proportions. When added to the copper in the form of a copper-silicon-iron alloy (of low melting-point) complete deoxidation is effected and, in addition, degasification is so thorough that perfectly sound ingots are obtained. In the absence of bismuth and other like impurities, which cause red-shortness in deoxidized copper, the ingots behave perfectly when rolled at a bright-red heat, even if silicon and iron are present together in considerable excess of the amount required for deoxidation.

It is shown that silicon is a more efficient deoxidizer than iron, but that iron has a greater strengthening effect than silicon.

Complete analyses of the rolled bars have been made and it is noteworthy that the added elements confer greater toughness than is possessed by "tough-pitch" copper containing oxygen and a similar quantity of arsenic. Heat-treatment of the experimental bars in a reducing atmosphere also proves their immense superiority over "tough-pitch" arsenical and non-arsenical bars.

The experiments have been backed up by works' tests on a larger scale.

[*] In the article of this serial, published in the October issue, the heading of the table on the bottom of page 563 should read: Safe carrying capacity in amperes (instead of amperes per square inch).

Tensile tests at the temperature of high-pressure steam show that the specially alloyed bars are in no way inferior to "tough-pitch" copper of similar arsenic contents.

The above-mentioned improvements have not been gained at the expense of any of the properties considered to be essential in commercial "tough" copper for locomotive stay-rods.

Certain physical characteristics of the experimental bars are revealed and differences in behavior explained by the aid of the microscope.

Notes on Chemistry and Metallurgy in Great Britain

(*By our Special Correspondent.*)

The British Association

The presidential address of Sir Oliver Lodge (published in full in the October issue of this journal), was generally very favorably received by the daily press, but among scientific men the tone of that section of his address which dealt with "continuity" in relation to "life after death" is by no means so generally approved. There are many men with more than thirty years of "accumulated experience" of so-called psychological matters who are still without any evidence, positive or negative, on the matter.

It was a pity that Sir Oliver did not give some indication of the nature of the evidence furnished by his experience, because at present there is really nothing in the shape of evidence one way or the other. We have only the disreputable tricks of spiritualistic mediums, which would not delude an average child of ten; and scientific men are not inclined to regard such impostures as evidence or even to notice them at all. In really scientific circles the number of men is steadily increasing who are content, like Huxley, "to follow Socrates in the belief that "the knowledge of what we do not know is perhaps the surest; "and to hold that those who do not attain that knowledge, who "presume beyond human limitations, are rightly visited with "the punishment of becoming the slaves of their own delusions, "the worshippers of idols, which are their own works as much "as if they were hand made." [Huxley, Nineteenth Century, "March, 1895.]

The true essence of the whole matter is to be found in the preface to the Pious Editor's Creed in James Russell Lowell's "Biglow Papers," and although discussion may be just as much out of place in these columns as it is in the meeting, to the British Association, the following brief extract from that preface may perhaps be of service in preventing anyone with psychological tendencies from searching too deeply after the unknowable:

"But the clergyman chooses to walk off to the extreme "edge of the world, and to throw such seed as he has clear "over into that darkness which he calls the next life. As if "*next* did not mean nearest; and as if any life were nearer "than that immediately present one which boils and eddies all "round him at the caucus, the ratification meeting, and the "polls! Who taught him to exhort men to prepare for eternity "as for some future era of which the present forms no integral "part? The arrow which Time is now turning runs through "the everlasting, and in that must he plant or nowhere. Yet "he would fain believe and teach that we are *going* to have "more of eternity than we have now. This *going* of his is "like that of the auctioneer on which *gone* follows before we "have made up our minds to bid."

Transmutation of Metals

Mr. **Frederick Soddy** in his discourse on "Radio Active Elements and the Periodic Law," explained how it was now possible in consequence of recent discoveries to assign their proper places in the periodic table of the elements to the disintegration series of radio-active materials such as uranium, thorium and actinium.

He said that the chemical analysis of matter had hithertto appeared to be ultimate, because it had been impossible to dis-tinguish between elements which were apparently chemically identical and not separable unless they were in process of change one into the other. But for those elements of which the evolution was still going on the places in the periodic table were found to be occupied on the average by no less than four, the atomic weights of which varied as much as eight units.

The same conditions were probably true for the rest of the table, and every known element might be composed of a group of non-separable elements, apparently occupying the same place, and the atomic weights would not be a real constant, but a mean value.

These advances showed that matter was much more complex than had hitherto been revealed by chemical analysis, and at the same time indicated that atomic constitution might be more simple than had been supposed from the lack of simple numerical relations between the atomic weights. These group-elements all gave the same spectra owing to similarity in their electronic system.

Madame Curie possessed about a gram of radium, and intended to compare the spectra of radium-lead and ordinary lead. He thought they would be exactly the same; but Madame Curie did not agree. He did not see any reasons why, under suitable conditions, it should not be possible to change thallium or mercury into gold. It only needed the expulsion of one alpha particle from thorium, which could be effected at a potential of 1,000,000 volts; but at present it was difficult to work with over 100,000 volts. Also, the expulsion of one beta particle and two alpha particles from lead ought to form gold, and the intermediate product would be bismuth.

Radio-Elements

Mr. **Alexander Fleck**, in the course of an interesting paper, said that since last year's meeting the study of the chemistry of the radio-elements had been continued, and the chemical nature of eleven additional radio-elements had been experimentally ascertained. It appeared that Uranium X and radio-actinium were chemically identical with thorium: meso-thorium—2 was chemically identical with actinium: radium-A was chemically identical with polonium; radium-C, thorium-C, actinium-C, and radium-E were chemically identical with bismuth; radium-B, thorium-B, and actinium-B were chemically identical with lead; and finally thorium-D and actinium-D were chemically identical with thallium.

The Effect of Exposure to the Atmosphere on Metallic Wires

Mr. **Ernest Wilson** presented a report on the results of tests designed to show the effect of exposure to London atmosphere on the electrical resistances of various metallic wires having a diameter of 0.126 in. and a length of 70 ft. These tests are a continuation of Mr. Wilson's earlier experiments of the same nature, the results of which have been communicated to the Association for some time past. The figures now given show the percentage increase in electrical resistance, at 15 deg. C., on the value found in 1911, and are for two years' exposure. High conductivity copper showed an increase of 2.0 per cent; commercial aluminium, 4.4 per cent; and "Duralumin", 8.2 per cent. In the last named metal exposure has apparently induced some increase in brittleness.

Wrought Iron for Rolling Stock

The Engineering Standards Committee has issued a new specification embodying considerable alteration from the specification of August 1910. Among the more important changes are:

(1) A reduction in the number of tensile tests for best Yorkshire bar iron; (2) A similar reduction in the number of bend tests; and (3) the deletion of the quenching test; (4) the inclusion under grade "B" of the tests for plates which were included under grade "C", but with a slightly increased minimum elongation per cent, and somewhat more severe bend tests, and the insertion under grade "C" of plates of Cleveland iron quality; (5) an increase in the minimum contraction of area per cent. of original area for grade "A"

round and square bars up to 1½ in. in diameter or section; (6) an increase in the minimum contraction of area per cent. of original area for grade "B" round and square bars up to 1¼ in. in diameter or section; (7) the optional use of standard test pieces B or F for the angles and flat bars up to 1 in. in thickness; (8) the provision of bend test pieces for blooms and billets, for bars over 2½ in. in diameter or section, and for flats over 1 in. thick; (9) provisions for testing other blooms and billets; (10) the deletion from the tables of tensile tests of the requirements for round or square bars above 4 in. in diameter or section; and (11) the addition of a quenching test for grade "B".

The Anti-Corrosive Properties of Coal Tar

Experiments conducted by the Military Engineering Department at Brest show that the value of dry tar as a preservative of ironwork from corrosion is greatly increased by the addition of quick-lime which has the effect of rendering the coating more durable, especially in the neighborhood of sea-water. Two parts of coal tar were heated to boiling in a cast iron pan and were then triturated with one part of lime. At a temperature of about 50 deg. C., the mixture can be applied by a brush in a thin, uniform coating after the iron has previously received a coat of red lead, and drying is complete in about two days. A metal door so treated showed no sign of corrosion after 12 months, whereas ordinary paint did not withstand the action of the brackish atmosphere for more than six months. The total cost of red lead, tar compound and labor amounts to about 8d. per square yard.

Coal-Dust Explosions

The recently-published fourth report of the Explosions in Mines Committee gives the very interesting results of the experiments carried out by Dr. Wheeler in the Altofts gallery for the Mining Association of Great Britain.

The combustion of a mixture of coal-dust and air appears to proceed in two distinct stages; first, inflammation, and next explosive combustion; and in the earlier stage flame is propagated to a great extent by the combustion of gases resulting from the ignition of the dust, while in the explosive combustion stage the dust particles are entirely consumed—fixed carbon as well as volatile matter—without notable preceding liberation of gas. The times of travel and pressures at various distances recorded in experiments in which ignition was effected 500 feet from the open end of the unobstructed gallery pointed to the conclusion that combustion remained of the "inflammation" order for about 425 feet and then suddenly assumed the explosive character.

The violence of the explosive effect of a mixture of air and coal dust was found to be just as great with dust containing 16 per cent. of volatile matter as with dust giving 35 per cent. of volatile matter, and the effect produced with wood charcoal was fully as great as with coal dust. When the gallery was free from any obstruction the pressure produced at a distance of 450 feet from the point of ignition was only 16 lb. per sq. in., but when timbers, to represent roof-props in a mine, were introduced a pressure of 50 lb. per sq. in. was registered at a distance of only 225 feet.

Other experiments in which constrictions formed by 6-in. flanged angle iron, reduced the the diameter of the gallery from 7 ft. 6 in. to 6 ft. 6 in. showed conclusively that the maximum pressure developed increased very largely, and, under certain conditions, was attained at much less distance from the point of ignition, while the time in which it was reached was very much reduced.

With three constrictions at 300, 350 and 400 feet from the point of ignition a maximum pressure of 152 lb. per sq. in. was developed at a distance of 450 feet as against 16 lb. per sq. in. in the clear tube. Three constrictions placed at 200, 250 and 300 feet from the ignition point resulted in a maximum pressure of 57 lb. per sq. in. at a distance of 250 feet in 66 hundredths of a second as against a pressure of 10.5 lb. at 350 feet in 1.03 second with one constriction at 200 feet.

The Co-Ordination of Engineering Research

At the summer conference of the Institution of Mechanical Engineers Mr. G. H. Roberts presented notes on engineering research and its co-ordination. He said that whilst engineering had reached a high stage of development as an applied science, it was remarkable that no definite system existed for communicating to the profession as a whole the results of numerous private researches which are carried on. He referred more particularly to that class of work which had a direct object in view and did not extend to side issues, and which in this country alone must be very extensive. Typical examples were furnished by the reports of the American Board of Ordnance; and there had also recently been an increasing tendency on the part of the engineering departments of our largest railway companies to interchange information.

The President, Sir H. F. Donaldson, in his presidential address delivered in April, had advocated the establishment of an engineering research committee on the lines of the Engineering Standards Committee, and the President of the Institution of Water Engineers had last June expressed the opinion that the results of very much experimental work were lost because they were not properly recorded; and when satisfactory records were kept the investigator retained his results. Railway companies and government establishments were probably least affected by considerations of competition, yet even in their cases certain investigations must be of a confidential nature.

At Woolwich Arsenal there were the ordnance factories and the inspecting and stores department of the army and navy; and the ordnance factories comprised three separate manufacturing establishments for the production of warlike stores. Each was especially concerned in its own class of manufactures; and it therefore followed that the laboratory researches were in some degree restricted to their own productions; but the great variety of material produced necessarily resulted in a certain amount of over-lapping, and a recognition of this fact led to arrangements being made some time ago for all experimental researches to be communicated to all departments. In addition, all the leading English and American engineering journals had been extracted, and the information so obtained was systematically recorded and indexed, and had constituted a valuable source of collateral information. With regard to methods of reporting results he did not advocate the use of stereotyped forms in every case, but he thought that for most of the tests now generally carried out standardized forms would be advantageous.

In the discussion Sir H. F. Donaldson said that as the Ordnance Factory at Woolwich had found that inter-departmental communication of research results was useful, it was to be hoped that the system would be followed in a wider field, and that private firms would assist in the co-ordination of research.

Professor Arnold said that at Sheffield the difficulties attending the co-ordination were being met by the establishment of a club consisting of three classes of members, namely, university graduates and associates, practical works, metallurgists, and the manufacturers.

Mr. Alexander Siemens spoke of the way in which the Siemens works in different countries co-operated in research work, and said that the plan which had been described was actually in operation between their establishments in London, Berlin, St. Petersburgh and other places. But it was questionable if firms less intimately connected would take part in arrangements for making the results of their research generally available. There were firms who would not be willing to publish the results of their research, whilst they would gladly take advantage of the published results of what others had done.

Your correspondent is not alone in the opinion that, however desirable the co-ordination of research may be, it is not likely to be brought into operation in the immediate future, at all events, in England as far as manufacturing firms are

concerned, although something is to be hoped for in the direction of the collaboration of technical institutions and university laboratories for systematized research. The analytical and scientific chemist almost invariably publishes the results of his research, but this is not the case with the manufacturing chemist, who, as a rule, jealously guards against any divulgence of his processes, which he, with some justification, regards as private property; and it is not to be expected that manufacturing engineer will be more ready to publish the results of his research than the manufacturing chemist, unless and until it can be demonstrated to him that he as well as others would benefit. The results of research undertaken for a definite object are just those which a private manufacturere or firm would be most unlikely to give away. There may be here and there an instance of the class last alluded to by Mr. Siemens; but vastly preponderating numbers of English manufacturers prefer to rely on their own experience and their own investigations.

The Supply of Tungsten in England

In *The Times* of the 13th August an anonymous correspondent stated that all the wolframite and scheelite produced in Cornwall or imported to Great Britain from the Colonies and abroad is sent to the Continent to be smelted into tungsten, of which a proportion is returned for the manufacture of electric lamps and a very large amount for the manufacture of tungsten steel. He further stated that there is no factory for producing the metal in this country, and pointed out that in the event of a European war in which England is involved the supply of tungsten would be cut off whilst the demand would largely increase.

But a week later *The Times* published a communication from a Luton firm stating that their works are now turning out many tons of ferro-tungsten a week in England, and are not only sending large supplies of that product to Sheffield but also to Russia, Austria, Germany and elsewhere.

Engineering Imports and Exports

The returns issued by the Board of Trade for the eight months ended on August 31 present figures which compare very satisfactorily with those for the corresponding period of 1912; but the statistics for the month of August exhibit considerable decreases in the value of most classes of engineering materials and products.

For the eight months the imports of iron and steel, including manufacturers, totalled £10,000,475, an increase of £1,938,248, and exports touched £36,841,732, an increase of £6,944,838. Other metals, including manufactures, were imported to the value of £21,571,818, an increase of £1,678,011, and were exported to the value of £8,949,586, an increase of £1,451,170. In electrical goods the imports amounted to £988,925, a rise of £67,118; and exports reached £3,477,085, an improvement of £764,671. Imports of machinery with a total of £4,922,334 show an increase of £415,517; and exports went up to £24,422,003, an advance of £3,260,284. The value of imports of new ships was only £24,223, a drop of £684; but exports rose to £8,318,951, an increase of £4,606,702.

The month of August, however, taken alone, shows extensive decreases. Imports of iron and steel were £49,918 less, and exports fell £51,583; imports of other metals decreased £254,-215, and exports were £28,011 lower; electrical goods increased £16,781 in imports, but exports went down by £67,477; imports of machinery rose £5,021 and exports improved by £151,746; imports of new ships declined £2,354, while the exports increased by £2,246,506.

Market Report, September, 1913

	£.	s.	d.
Aluminum ingots in ton lots, per ton	96.	0.	0
Alum, lump, ton	5.	10.	0
Antimony, ton	30.	0.	0
Borax, Brit. refined crystal, cwt.	18.		6
Copper Ore, 10 to 25% unit	12/10½ to	13.	4½
Copper sulphate, ton	24.	0.	0

		£	s.	d.
Caustic Soda, 70%, ton	10.	5.	0
Ebonite Rod, lb.		4.	6
Hydrochloric Acid, cwt.		5.	0
India Rubber, Para fine, lb.		3.	7
Mica, in orig. cases, medium	3/6 to	6.	0
Naphtha, Scotch, gal.			11
Petroleum, Russian spot, gal.			9¼
Quicksilver, bottle	7.	5.	0
Sal Ammoniac, lump 1sts, del. U. K., ton	44.	0.	0
Tin Ore, 70%, ton	£123 to 125.	0.	0
Sulphuric Acid, cwt.		5.	6
Lead, peroxide, ton	27.	10.	0
Potassium Bichromate in casks, lb.			3½
Zinc, sheet, Vielle Montagne	26.	10.	0
Shellac, cwt.	4.	18.	0
Sulphur, recovered, ton	5.	10.	0
Platinum, oz.	9.	5.	0

Tin opened £193 and rose smartly to £197 on the 4th, then dropping away to £193, recovering to £194.15.0 on the 16th, then again falling away, till £190.5.8 was reached on the 22d. During the last week it rose to £195.5.0, but demand being satisfied, subsequently fell touching £191, and closing £189.5.0.

Copper opened at £71 and rose, exhibiting considerable strength, till by the 16th it had reached £75. It then fell to £72¾ by the 22d, rose sharply to £74 on the 23d, and after another dip to £72⅝, rose to £75.10.0 by the 24th, but ultimately gave way to depression caused by labor trouble, and closes £72.10.6.

Lead opened at £20.15.0 and was inclined to go higher during the first week, but afterwards settled down, showing a maximum of 20¼ and a minimum of 19¾ (rumors of unexpected stocks over the greater part of the month. It closes £20.10.0.

Iron, Haematite opened 67/-, but rose 67/3 by the 8th, then flat, afterwards irregular. It reached 67/3 on the 16th and closes 67/3.

Scotch Pig opened 62/- and fell away, being 60/3 by the 15th, then recovering slightly reached 60/9 by the 19th, and closes same price.

Cleveland opened 56/- but declined after the 3d, being 54/9 on the 10th and 54/3 on the 15th. It had recovered by the 19th to 54/9 and closes at that price.

DIFFERENCES

Higher	£. s. d.	Lower	£. s. d.
Copper Sulphate	2.10.0	India rubber, Para, lb.	2½
Copper Ore, unit	2.0	Shellac, cwt.	2.0
Sal Ammoniac, ton	2. 0.0	Tin	3.15.0
Tin ore	8. 0.0	Scotch Pig	1.3
Zinc, V. M.	1. 5.0	Cleveland	1.3
Copper	1.10.0		
Haematite	.3		

Market Prices, August, 1913

	£	s.	d.
Aluminium, 98-99%, per ton	87.	0.	0
Alum, lump loose, per ton		5.10.	0
Antimony, Star Regulus		30.	0. 0
Borax, Brit. refined crystal, ton		17.10.	0
Copper sulphate, ton		21.10.	0
Copper ore, 10-25%, unit	10/10½ to 11.		4½
Ebonite rod, per lb.		4.	6
Hydrochloric acid, cwt.		5.	0
India rubber, Para fine, lb.		3.	9½
Mica, in orig. cases, medium	3/6 to 6.		0
Petroleum, Russian spot, gal.			9¼
Quicksilver (Spanish), bottle	7.	5.	0
Sal ammoniac, lump, firsts, ton	42.	0.	0
Sulphate of ammonia, f.o.b. Liverpool, ton	13.	5.	0
Sulphur, recovered, ton		5.10.	0
Shellac, cwt.		5.	0. 0
Platinum, oz., normal		9.	5. 0
Tin ore, ton	£115 to £117		
Zinc, Vieille Montagne, f.o.b. Antwerp	25.	5.	0

better; imports of electrical goods increased £26,029, and exports advanced £215,670; machinery showed increases of £80,133 in imports and £373,181 in exports; new ships rose by £1,627 in imports, and exports improved to the extent of £732,965.

Tin has been fairly steady. Opening £186.0.0 it rose till the 12th when it touched £190.10.0, and then fell to £188, remaining for a week about this level till the 26th, when it again rose and closes £194.5.0.

Copper has not maintained the promise of a sharp rise which appeared to be probable in the middle of last month. Opening at £67.2.6 it reached £69.5.0 on the 9th, but fell to £68.15.0 by the 21st, but recovered and closes £71.0.0.

Hematite fell away considerably during the month. Opening at 71/9 it had dropped 2/– by the 6th, and another 2/– by the 21st. It closes at 67/–.

Scotch Pig opened 64/– and closes 62/–.

Cleveland opened 54/10 and did not show much activity till the end of the month. On the 24th it was 54/4, on the 28th 55/1½ and closes at 56/–.

Lead, opening high, £21.5.0, dropped to £19.3.4 on the 18th, and was £20 on the 22d, closes £20.15.0.

DIFFERENCES

Higher.		*Lower.*	
£ s. d.		£ s. d.	
India rubber	1	Aluminium	1. 0. 0
Sulphate of ammonia.	8. 9	Alum	10. 0
Sulphur recovered....	5. 0	Hematite	4. 9
Shellac	7. 0	Scotch Pig	2. 0
Zinc	10. 0	Lead	10. 0
Tin 12. 0. 0			
Copper 3. 17. 0			
Cleveland............. 1. 1½			

Synopsis of Recent Chemical and Metallurgical Literature

Electric Furnaces

Comparison Between Electric and Fuel Furnaces.—Anticipating the wider adoption of the electric furnace in metallurgical work within the next few years, Mr. F. Louvrier calls attention to the points of advantage in the electric furnace, in an article in the *Mexican Mining Journal* for September, 1913. Citing the fact that the electric furnace has "completely conquered the metallurgy of aluminium," and is used in the manufacture of steel, steel alloys and pig-iron, Mr. Louvrier makes the forecast that "at no distant date electricity will be applied in large scale to the treatment of all ores." The cause of this progress is ascribed to the superiority of the electric furnace over those now employed, the heat being produced electrically instead of by the combustion of fuel.

In considering fuel-burning furnaces, the author divides them into two classes: those in which the ore is in direct contact with the fuel, and others in which the ore is more or less completely separated from the fuel or products of combustion. It is evident that the thermic efficiency of the former type is greatly superior to that of the latter. By calculating the heat available from the combustion of carbon under operating conditions, and comparing it with that obtained in an electric furnace of the resistance type, the author reaches the conclusion that: "One electric horsepower per year is equal to 2700 kg of coke consumed in the ordinary furnaces." Comparing further the costs of the two thermic agents under different conditions, he arrives at the conclusion that the employment of electric furnaces is from two to five times as cheap as coke furnaces.

To this economy he adds the following advantages of the electric furnace:

1—Facility of regulating heat by simple handling of the electrodes or interrupters.

2—Constant production of the exact heat necessary, no matter what its intensity.

3—Elimination of the chilling of slags, so prejudicial in coke furnaces.

4—Easy treatment of all classes of ores, no matter how refractory.

5—Higher percentage of the recovery of metals as a consequence of (a) the non-oxidizing action of electric heat, which is produced without air or oxygen; and (b) the production of less and more fluid slag.

6—Decrease in manual labor due to less quantity of material to be handled, and because the ores can be treated as they come from the mines without crushing or briquetting.

7—Complete suppression of blowers and tuyeres.

8—Decrease in expenses of maintenance and repairs due to the maximum temperature being in the center of the ores treated and not on the walls of the furnace.

9—Production of purer metals; the electrical heat being chemically neutral and not introducing impurities contained in the usual fuels.

10—Possibility of operating profitably those mines situated in remote places, due to facility of transmitting electrical energy.

11—In all cases, decrease in transportation expenses, due to facility of treating ores at the mines.

12—Yields as high from small plants as from large ones.

Considering the above advantages as accruing in the case of metallurgical furnaces in which the ore and fuel are in contact, the author concludes that the economies of the electric furnace will be still further emphasized in the case of indirect firing. In the latter cases the following advantages of electric energy may be added to those enumerated above:

1—In the furnaces used for tin ores, one electric horse-power per year is equal to 3600 kg of coke, and yields a greater quantity of tin because the metal is neither oxidized nor carried away in the form of vapor.

2—In furnaces used for zinc reduction, one electric horse-power per year is equal to 7000 kg of coal, and the percentage obtained is not less than 95 per cent against 85 per cent by ordinary processes.

3—In the manufacture of crucible steel, one electric horse-power per year is equal to 18 tons of coke, this proportion being due to the high temperature required.

As the generation of one electric horsepower per year produced in gas engines calls for a consumption in coal of not more than 3855 kg, it can be concluded that in the treatment of tin ores, and, above all, of zinc ores, as well as in the manufacture of steel alloys and crucible steels, the use of electric furnaces is more advantageous, even should the electrical energy be produced by thermic engines consuming fuel.

Gold and Silver

Assay of Gold and Iridium in Black Sand.—Among the prizes offered in the Chemical, Metallurgical and Mining Society of South Africa, was one of twenty guineas by the Witwatersrand Co-operative Smelting Works, Ltd., for the best method of assaying gold in the presence of iridium and allied metals in such materials as black sand. The committee on awards selected two of the papers submitted as being superior to all others, although the committee was not fully satisfied that the authors had adduced sufficient evidence that the methods proposed would be wholly accurate and reliable. The following abstract of the. two methods is taken from the July, 1913. *Journal* of the Society, in which the papers are published in full, with experimental data and bibliographies.

Method of James Gray.—From 0.5 to 2 A.T. of the material is assayed in the usual manner, and the button cupelled. The weight of this button gives the quantity of silver, gold and iridium. Owing to the tendency of the platinum metals to cause the button to scatter over the cupel, it may be necessary to add silver to the assay in order to obtain a single bead. In any event an excess of silver must be present prior to parting. The button is then flattened or rolled, and treated with hot concentrated sulphuric acid which dissolves the silver. The residue is washed and weighed, giving the weight of gold and

platinum metals. This residue is then dissolved in aqua regia, and the solution filtered to remove any insoluble platinum metals. The filtrate is made alkaline with caustic soda, the change from deep yellow color to almost white being easily noticed. From 10 to 20 cc. hydrogen peroxide (20 vols. quality) is then added, whereupon the gold comes down immediately as a black precipitate.

$$2AuCl_3 + 3H_2O_2 + 6KOH = 2Au + 3O_2 + 6KCl + 6H_2O$$

The mixture is then boiled for about ten minutes and filtered. After washing, it is run down in a crucible with borax, litharge and reducing agent, or scorified, and the resulting lead button thus obtained cupelled. The gold is weighed, and the difference in weight between it and the gold plus platinum metals gives the weight of the latter.

It is advisable to run a blank on pure gold simultaneously and add the loss thus observed to the weight of gold recovered. Ordinarily 99.5% of the gold is easily recovered. In the case of dilute solutions it is advisable to acidulate after the oxygen has been expelled by boiling.

The platinum metals may be recovered from the filtrate by means of sulphuretted hydrogen, and determined according to the methods of Leidie and Quennessen. The residue insoluble in aqua regia, as stated above, may be recovered in a convenient form by cupelling the filter paper.

Method of Chris Toombs.—One A.T. of the black sand is roasted at a scarcely perceptible dull red heat until sulphur-free. It is then fluxed as follows:

Black sand	1	A. T. (roasted)
Soda carbonate	2	A. T.
Borax	1½	A. T.
Litharge	1½	A. T.
Flour	4	gm.
Silver	q.s.	

The mixture is placed in a paper bag and dropped into a red hot crucible. The assay is conducted at red heat until fusion is complete, and finished at nearly white heat. Wash with a mixture of litharge and flour, pour and cupel. Blanks of pure gold and silver should be cupelled at the same time. The resulting buttons are flattened, annealed, rolled and annealed, and parted in porcelain crucibles with dilute nitric acid ($5HNO_3$ to $12H_2O$). Bring the acid to a boil, cool to about 80°C. and throw in the cornet. Action should be brisk but not violent. Heat to nearly boiling without actual ebullition; decant, wash and anneal carefully to avoid sticking iridium to crucible. Weigh gold and iridium together. Dissolve gold with 1 cc. 10% aqua regia in a long test tube; filter off the iridium, wash, dry and ignite over a bunsen burner. Weigh and make a deduction for the filter ash. Subtract this weight from that of the gold and iridium, obtaining the weight of fine gold in the 1 A. T. fused. Make proper correction as observed in the blank checks. If it is desired to recover and weigh the gold separately, the solution is neutralized with NaOH, added to a little NaCN solution, and precipitated with Cu_2Cl_2. The precipitate is filtered, washed, scorified and cupelled.

Zinc Wafers for Precipitation of Cyanide Solution.—In our synopsis of current literature in April, 1913, page 219, we noted a new method of precipitation for gold solutions, making use of zinc wafers 1 to 2 in. long and ¼ to ½ in. wide, instead of the usual zinc shavings. Excellent results were reported by Mr. John S. MacArthur. In the May, 1913, *Journal* of the Chemical, Metallurgical and Mining Society of South Africa, Mr. E. G. Baskett reports his experience with the use of this form of precipitation and gives decidedly unfavorable results, adding, however, that the conditions were not the same as those under which Mr. MacArthur obtained good results, and that more favorable conditions might give better results.

Mr. Baskett tried the method at the City and Suburban Mill, taking the special precaution to fill the lower compartments of the experimental box with zinc shavings in the usual manner. Four compartments were used for wafers and three for shavings, an intervening compartment being left empty and tapped at the side to obtain samples. With a flow of 10.5 tons solution per cu. ft. zinc per 24 hours, the extraction by

the wafers was but 35 per cent. On reducing the flow to 5.27 tons, the extraction was not improved, but fell to 31 per cent. White precipitate accumulated on the zinc wafers, and after 24 hours' running about 25 per cent. of the zinc surface was rendered inert. On cleaning up after ten days' working, the wafers in the top compartment were found to have formed almost a solid mass with white precipitate. On examination of the wafers with a lens the whole surface was seen to be coated with a thin film of white precipitate which could not be removed by washing. The gold slime recovered contained only 1.41 per cent fine gold, the balance being white precipitate.

The experiment was repeated with stronger solutions coming from the sand vats, but was not more successful. After two days the whole precipitate appeared. The recovery was only 32 per cent.

Tin and Copper

The crude methods of smelting tin adopted by the natives of Mexico, in the vicinity of San Luis Potosi, are described in an article by Mr. GEORGE C. MASTER in the *Mining Magazine* for September, 1913. The work is done in a desultory manner by roving bands of tin miners who work in cooperation with the owners of ranches on whose lands tin deposits occur. The work is frequently profitable from the beginning of operations, as the miners work only exposed outcrops and quit when the vein pinches. The ore is crushed by hand to about ¼-in. size, sorted and washed in a planilla and finally in a wooden batea. A planilla is a hole dug in the ground, about 5 ft. long, 3 ft. wide at the upper end and 2 ft. at the lower, with a sloping surface of from two to five degrees. At the lower narrow end, there is a cup-shaped hole in which the water collects. The depth is only a few inches below the surface, and stones are placed at the sides to prevent loss of water and mineral. The process of concentration consists in placing from 60 to 120 lb. of ore at the upper end of the planilla, and filling the role in the lower end with water. The latter is then thrown over the ore by means of a horn cup, and the lighter gangue is washed down the sloping surface, leaving the heavier cassiterite above. This process is repeated at least twice, after which the concentrate receives a final washing in a wooden batea, a form of concentrating pan. The concentrate thus obtained averages from 45 to 65% tin, according to conditions.

The blast furnace constructed by these natives is made of any hard stone cemented with clay called *tierra del fuego*. The dimensions of the furnace may be: height, 2 ft. 6 in.; top feed opening 5 in. square; front inside vertical, but back and sides sloping outward; inside diameter at bottom, 9 in. The bottom has a steep slope toward the open hearth in front, the latter being merely an excavation with a clay-lined floor. The blast is produced from two bellows, worked alternately by two men. The bellows are made of ox-hide; the nozzles unite, forming one tuyere made of a piece of iron pipe, placed about 8 in. above the furnace bottom. Before commencing operations, the furnace and hearth are lined with clay, and when dry, a charcoal fire is started. A light blast is admitted, and when the temperature has risen sufficiently, the moistened charge is fed, in the proportion of one part concentrate to three parts charcoal, by weight. When the furnace is smelting well, some hardhead obtained from previous smelting operations, is added. As much as 450 lb. concentrate may be smelted at one time, and when the operation is nearly finished, the slag is broken to 1 in. and resmelted. The treatment of 450 lb. concentrate requires 16 hours. The loss is approximately 10%. The tin is run onto the hearth every few minutes, and later rolled into parcels of 25 lb. weight. The metal contains from 90 to 96% tin. The cost for smelting 450 lb. concentrates is given at 16.20 pesos, or about $8 gold.

Electric Smelting of Tin Ore.—Particulars concerning some experiments made by the Gröndal-Kjellin Co., of London, in smelting tin ores in Cornwall, are contained in the *Revue Industrielle*. Pure ores yielded metal of 98% purity, and Bolivian ores containing about 50% tin and 15% iron, gave

metal of 92 to 97% purity. The latter could be further refined to a purity of 99.75% by blowing air through the molten mass. The energy consumed was 1700 kw-hours per ton; but this may be reduced to 1400 kw-hours, with an efficiency of 55%, by using two furnaces, one for the production of high grade metal and the other for treatment of rich slags. The process may be commercially profitable where hydroelectric power is available.

Copper Smelting at Messina, Northern Transvaal.—Reverberatory smelting of copper concentrates is in progress at the Messina copper mines in the northern Transvaal. According to the *South African Mining Journal,* the furnaces are small having a hearth area of only 23 ft. by 11½ ft. The capacity of each furnace is 20 tons of ore in 24 hours, and the fuel consumption is 7 to 8 tons of coal. Local coal has been found suitable for the purpose, and the limestone necessary for fluxing is also found in the neighborhood of the mines. The first matte produced contained 65% copper, but later operations were conducted to yield a matte of 50% copper. Additions are being made in the way of roasting furnaces, and it is expected that ultimately converters will be added.

Ore Dressing

Need of Better Classification.—In considering the improvements in ore treatment necessary to permit the utilization of lower grade ores, Prof. ROBERT H. RICHARDS, of Boston, Mass., believes that better and more extensive classification is one of the requisites. His paper on the subject appears in the September *Bulletin* of the American Institute of Mining Engineers. The following incident illustrates Prof. Richards' contention: A three-pocket cone classifier in a small mill had a feed ranging from 2 to 0 mm., and supplied four Wilfley tables. The first spigot had about all the sand and a great deal of slime; the other spigots and the overflow were about all slime. As a result all tables carried wide bands of slime and their tailings were charged with fine free mineral. The mill work was greatly handicapped by lack of good classification, for it is a proved fact that when the feed to a Wilfley table carries slime, then the tailing will carry fine free mineral. When this same ore was tested in the laboratory, it yielded easily 12 spigot products, all of which, when fed to Wilfley tables, gave no bands of slime on the tables; and free fine mineral was absent from the tailings of the coarser tables, and present only in small quantity in a few of the finer.

The benefit of this extended classification will be apparent from the following tables, showing the relative sizes of quartz and galena in the spigot products and overflows from a 3-spigot and a 12-spigot classifier.

Three-spigot Classifier

Spigot	Quartz. Diameter, Millimeters	$\dfrac{1}{3.5}$ of the quartz is galena. Diameter, Millimeters
1	6.30 to 2.15	6.30 to 0.614
2	2.15 to 0.73	0.614 to 0.208
3	0.73 to 0.25	0.208 to 0.0715
Overflow	0.25 to 0.00	0.0715 to 0.0000

Twelve-spigot Classifier

Spigot	Quartz. Diameter, Millimeters	Galena. Diameter, Millimeters
1	6.30 to 4.79	6.30 to 1.37
2	4.79 to 3.66	1.37 to 1.05
3	3.66 to 2.80	1.05 to 0.80
4	2.80 to 2.14	0.80 to 0.61
5	2.14 to 1.63	0.61 to 0.47
6	1.63 to 1.26	0.47 to 0.36
7	1.26 to 0.96	0.36 to 0.27
8	0.96 to 0.73	0.27 to 0.21
9	0.73 to 0.56	0.21 to 0.16
10	0.56 to 0.43	0.16 to 0.12
11	0.43 to 0.33	0.12 to 0.094
12	0.33 to 0.25	0.094 to 0.071
Overflow	0.25 to 0.00	0.071 to 0.000

Here we have limited and extended classifications of the same material, say quartz and galena. With free settling, the classified products, after the first spigot and before the final overflow, will contain grains where the quartz is approximately 3.5 times the galena in diameter. If we compare any two products, eliminating the first and last, both of which require special treatment, it will be clear that a Wilfley table treating spigot 2 of the three-spigot classifier, which has to separate 0.614 to 0.208 mm. galena from 2.15 to 0.73 mm. quartz, will not have so easy a task as the table which treats spigot 2 from the twelve-spigot classifier and has to separate 1.37 to 1.05 mm. galena from 4.79 to 3.66 mm. quartz. The same opinion holds with regard to the third spigot of the three-spigot classifier and the twelfth spigot of the twelve-spigot classifier; and is true also of all intermediate spigots.

"Next, let us see what a long classifier with many spigots will do, which a short classifier cannot do. We shall find, as follow on down from the coarser spigots toward the finer, that Wilfley tables will yield tailing products free from fine free mineral and, therefore, at the minimum assay that can be obtained without further regrinding. After a time, however, we shall arrive at a spigot where the heavy mineral in the spigot is the same size as the normal size of Wilfley fine free mineral. Then the Wilfley table breaks down, can no longer yield clean tailing, and the vanner should take its place, because the fine free mineral in the vanner tailing is smaller than that in the Wilfley table. If we follow still further down the spigots we shall find a spigot or the final overflow where the size of the heavy mineral is the same as the size of the fine free mineral in the vanner tailing. Then the vanner breaks down, can no longer yield clean tailing, and we go to the new great Anaconda round table, which takes all the rest down to the size of the heavy mineral that floats away in a slow-moving stream of water. With this the methods of water-gravity separation of fine material, that are now in sight, close."

The author goes on to show that the slime is not unduly diluted by using so many pockets in a classifier, provided steady and uniform feed is supplied. He concludes by showing the enormous sums that could be saved by good classification, and says "that we need better classification, more classification, and higher-priced, broader-minded men to see that the greatest benefit is derived from the improved machinery."

Recent Chemical and Metallurgical Patents

Iron and Steel

The preliminary preparation of fine ore and flue dust for smelting in the blast furnace, is the subject of a patent granted to Messrs. HARTLEY C. WOLLE and EDWARD F. KENNEY, of Westmont Borough, Pa. The invention consists essentially in compressing fine materials into a compact mass by passing a steady and uniform feed of these materials between rigid rolls, forming a thin sheet which subsequently breaks into flakes suitable for blast furnace work. The inventors' idea is to treat ore and flue dust that is finer than 1/16 or ⅛-in. mesh, and pass the same between rolls set ⅛ or ¼ in. apart. The rolling pressure compacts the loose material, giving a product which has a greater surface density than exists in its interior portion, and which is at the same time porous enough for blast furnace smelting. Actual experiments with natural ores show that moisture must be present within the limits of three and eleven per cent. (1,073,381, Sept. 16, 1913.)

Preheating Air for Metallurgical Furnaces.—In Fig. 1 is illustrated the embodiment of an invention of Messrs. JOHN W. HAMILTON, JR., and JOHN W. JOHNSON, of Coatesville, Pa., designed to preheat air in a manner that will eliminate the use of costly checkerwork. The heat radiated at the hearth of the furnace is utilized to bring the air to the proper temperature, particularly for use in gas-burning furnaces. Referring to the figures, A is a furnace of the continuous type for heating ingots and blooms *x*. B is the heating chamber and C is the outlet to the stack. D is the inlet flue for gas,

and E is an air duct communicating with D by means of *e*. The ingots or blooms travel on water-cooled rails *b*, *b*, which are supported at intervals on piers b^2. The hearth B^1 is directly under the main combustion chamber of the furnace. Located under the hearth are two air chambers I, side by side,
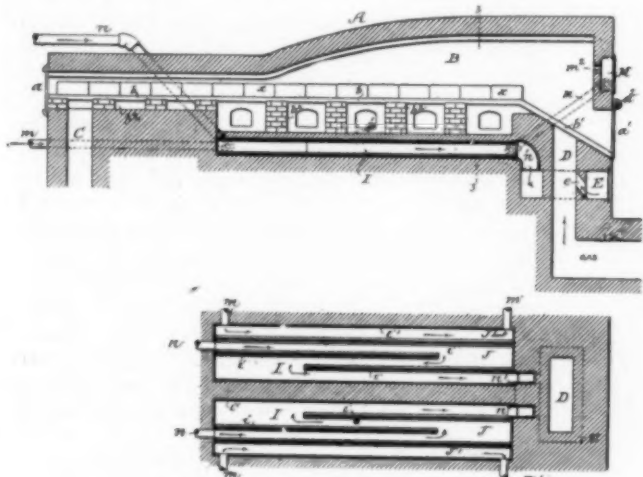

FIG. 1.—METHOD OF PREHEATING AIR

and there is only one layer of fire brick between these chambers and the combustion chamber. The plan of the air chambers is shown more clearly in the lower diagram of Fig. 1. Air is forced from a fan or blower into the passage *n*, traversing the chambers J and I, and issuing at n^1 to the air chamber E which communicates with the gas flue D, where it is mixed with gas prior to combustion. Auxiliary heated air
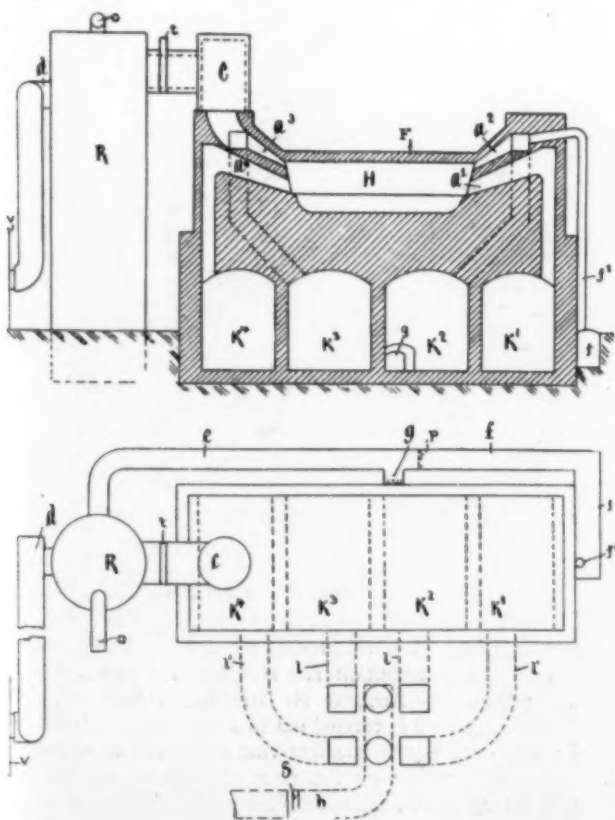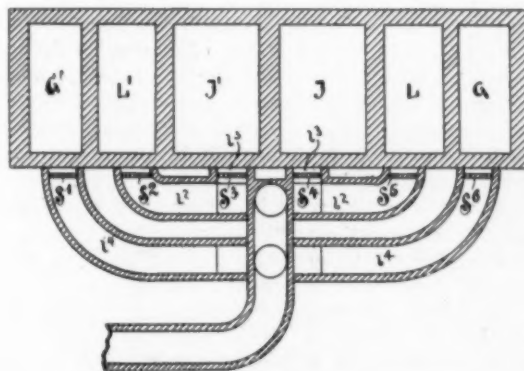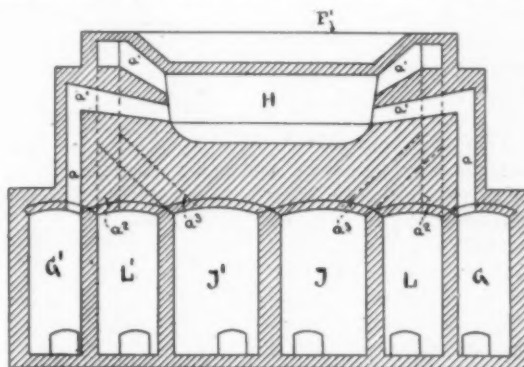

FIGS. 2 AND 3.—OPEN-HEARTH FURNACE CONSTRUCTION

passes through the straight side chambers J^1, entering at *m* and issuing at m^1 to the chamber M located above the outlet door of the furnace, and passing into the combustion chamber by passages m^2. The amount of gas and air can be controlled by any suitable valve mechanism. (1,072,331, Sept. 2, 1913.)

Air-cooled Blast Furnace.—RICHARD H. STEVENS of Munnace by a current of air. This air is furnished by the blownace by a current of air. This air is furnished by the blowhall, Pa., patents the idea of cooling the walls of a blast furing engines or compressors, passes through the hollow metal jackets which form the shaft lining and proceeds in this preheated condition to the hot blast stoves, where it receives the high temperature required by the hot blast. (1,074,097, Sept. 23, 1913.)

Siemens-Martin Furnace.—When it is desired to recover and work up volatile metals or compounds contained in iron or in ferric oxid, KURT ALBERT of Wiesbaden, Germany, recommends to divide the open-hearth process into two periods, during the first of which the valuable volatile matters are recovered in an additional chamber arranged like the checker chambers. During the second period the steel is finished in the usual way and is safe from any admixture of undesirable elements, and furthermore the chambers will not become choked up. Thus the volatile metals or their oxids

FIGS. 4 AND 5.—OPEN-HEARTH CONSTRUCTION

from galvanized iron, tiniferous calcined pyrites and the like can be recovered. Figs. 2 and 3 show one arrangement of applying this process. The gases containing the volatile matter are drawn by a fan through the recuperator R and filtered in bags or other devices not shown. The chambers K_1 and K_4, also K_2 and K_3 serve for heating gas and air respectively. In Figs. 4 and 5 two additional air chambers, L and L', are shown through which the gases of the first period may pass, and in another arrangement shown in the patent specification the same purpose is aimed at by building two chambers, laterally outside of the regular furnace structure. The partitions of these auxiliary air chambers can be closed, each one individually, by a damper. This arrangement provides for a cleaning of the chambers while the furnace is working. (1,073,653, Sept. 23, 1913.)

Refining Iron and Steel by Means of Ferrochromium Alloy.—JOSEF BUECHEL of Wengern-Ruhr, Germany, claims that the known objectionable formation of carbides when alloying commercial ferrochromium with steel will be avoided

when the ferrochromium contains neither carbides nor oxides. When free from these elements it has a much lower melting point than ferrochromium produced by the ordinary electro-metallurgical process [?]. To this end the chromium alloys are treated for protection from oxidation by alloying with silicon, aluminum, calcium, barium or an alloy of iron, chromium and aluminium. This helps an expeditious and uniform distribution of the chromium in the metal bath. (1,071,873, Sept. 2, 1913.)

Lead and Zinc.

Process for Sublimed White Lead.—In the manufacture of sublimed white lead from ores and concentrates, difficulties are encountered in subliming all of the metal and in producing a pigment of uniform white color. To overcome these obstacles Mr. ERNEST E. BANES, of Strathfield, near Sydney, N. S. W., has patented certain apparatus and method of operating the same, whereby he claims complete sublimation of the lead, and zinc if contained in the ore, and the production of a pigment of uniform white color and consumption. In carrying out the invention, finely divided lead sulphide ore or concentrate is fed continuously into a furnace through a blow-pipeflame introduced through a tuyere opening. The particles are thus dispersed, and complete volatilization occurs in the enveloping oxidizing atmosphere, matting and slagging being avoided. The fume passes from the furnace and is collected in a suitable bag house.

FIG. 6.—FURNACE FOR SUB-LIMED WHITE LEAD

The material to be treated is ground preferably finer than 40-mesh, and introduced into the furnace in a blast of air and combustible gas, through two or more opposed blow pipes, which are directed toward a point a few inches above the level of the contained fuel bed. Hot air is blown through tuyeres toward the same point, and supplementary cold air enters the furnace tangentially through other tuyeres above the hot-air tuyeres. A plant for the manufacture of sublimed white lead according to this inventor's process would consist of a shaft furnace fitted with tuyeres as described and containing a bed of fuel; a gas producer; an air blower forcing air through a preheating chamber in the furnace flue; cooling chambers and bag house.

A sectional view of the furnace is given in Fig. 6, and the ore-feeding tuyere is shown in Fig. 7. Within the furnace a fuel bed 68 rests on a grate 13. Fire box and ash pit are accessible through close-fitting doors. Ore-feeding tuyeres are oppositely disposed, one being shown at 43. Hot-air tuyeres are placed at 45 and cold-air tuyeres at 47. The ore-feeding tuyere, shown in Fig. 7, consists of a rotating auger 58 which advances the ore fed at 62 to the nozzle where it is dispersed by a whirling jet of air entering at 53. The gas port is at 50. The rate of feed of galena is regulated by the speed at which the auger is rotated, and bears a fixed relation to the air pressure and gas volume delivered to the nozzle. This fixed relationship between supply of ore, gas and air is a matter
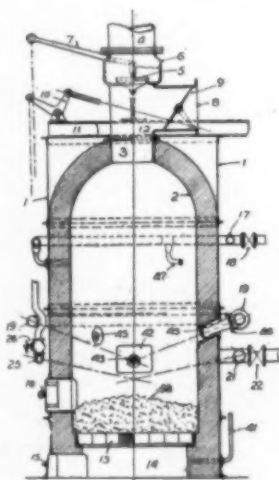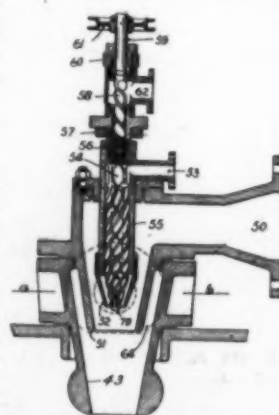

FIG. 7.—ORE-FEEDING TUYERE

of importance in the uniform operation of the furnace. The non-volatile elements contained in the ore fall as dust onto the fuel bed or are collected in the dust chambers. By grading the feed so that it contains a uniform percentage of galena, the product of the operation will be uniform. (1,073,462, Sept. 16, 1913.)

Lead Oxide for Storage Battery Plates.—An improved method of making amorphous lead oxide of low specific gravity and density, suitable for use in battery plates, is disclosed in a patent granted to Messrs. OLIVER W. BROWN and ALPHEUS R. NESS, of Bloomington, Ind. The product of their process is said to be more plastic and of higher tensile strength than similar pastes made from crystalline oxides. The required amorphous condition is obtained by heating basic or neutral lead carbonate, lead sponge, amorphous litharge or metallic lead at a temperature between 425 deg. C. and 440 deg. C. for a period of from three to three and one-half hours. (1,072,-205, Sept. 2, 1913.)

Extraction of Zinc from Slags.—Processes for the extraction of zinc from furnace slags have been proposed, based on mixing the slag with a reducing medium, briquetting and retreating in a furnace, whereby the zinc was volatilized and
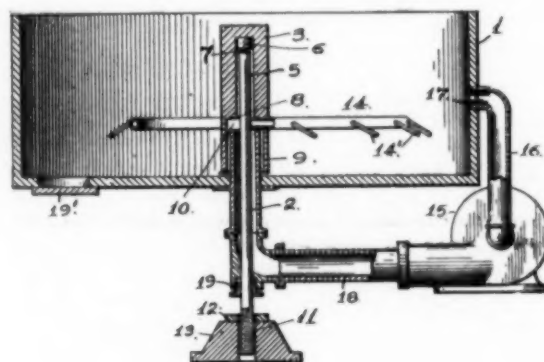
FIG. 8.—AGITATOR FOR ORE SLIME

collected as oxide. A novel process for treating furnace slags while in the molten condition, and removing the contained zinc oxide, is patented by ADOLPHE H. DESGRAZ, of Hanover, Germany. The operation is carried out in a reverberatory furnace, and depends on the principle that zinc oxide can be displaced from its combination with the ferro-silicates of the slag by adding a strong base, such as calcium oxide. The quantity of calcium oxide added to a molten slag is such as to give the resulting slag a lime content of from 25% to 35%. The zinc oxide being volatile, is collected in any suitable manner. (1,072,209, Sept. 2, 1913).

Gold and Silver.

Agitating Apparatus.—A device for agitating, mixing and aerating mixtures of solid and liquid, such as ore slime

and cyanide solution, is shown in section and plan in Fig. 2, being the invention of Mr. WALTER E. TRENT, of Reno, Nev. It comprises a hollow convolute distributing arm, provided with a series of outlet nozzles projecting from the forward surface of the arm and extending in a direction opposite to the travel of the distributing arm. Its principal object is to overcome the objections to similar devices in which the distributing arms extend radially from the center. Among such objections is the difficulty of starting the agitating mechanism after it has been allowed to remain at rest for a period, due to the packing of solid material around the arms.

Referring to Fig. 8 (p. 656) the material to be treated is fed into the receiving tank in any suitable manner, until it overflows the pipe 16 and submerges the tubular arm 14. The pump 15 is then started and the slime is circulated through the pipe 18 into the distributing reservoir 10, and thence through the arm 14 and nozzles 14'. Motion will be imparted to the arm, which will rotate and direct streams of slime from the nozzles to every part of the tank. Owing to the arrangement of the arm and nozzles, the material agitated will not be banked in front of the arm following, as the nozzles project from the forward surface of the arm. (1,073,878, Sept. 23, 1913.)

Chloridizing-Roasting of Ores.—Apparatus for applying a chloridizing roast to ores for the purpose of rendering their base and precious metals soluble, is shown in Figs. 9 and 10, being the patented invention of Mr. NIELS C. CHRISTENSEN, of Salt Lake City, Utah. The object of the apparatus and process is to treat an ore moistened with a saturated solution of alkali and alkaline earth chlorides, by successively roasting,

the mechanism 10. Beneath the deck is an annular sealed space divided into two portions 11 and 12, by the wide partitions 13 and 14. The part 11 is beneath the cooling portion of the hearth, and the part 12 beneath the roasting portion. These spaces are suitably sealed from the outside air. Above the deck is a stationary hood 17-18, divided into two chambers 20 and 21 by the partition 22; the part 20 is above the cooling stage of the deck and the part 21 is above the roasting stage.

The ore is charged onto the slowly revolving, perforated hearth in a uniform layer from the hopper 25, and is removed by the screw conveyor 26. The space above the roasting deck is connected by pipe 42 with the condensing tower 41. The fan 28 is connected with the space 11 beneath the cooling portion of the deck; and the fan 31 is similarly connected with the space 20 above the cooling portion, and also by pipes 33, 34

FIG. 10.—SECTION OF CHLORIDIZING ROASTING FURNACE

and 35, with the combustion chamber 36 which opens into the space 12 beneath the roasting portion of the deck.

In operation, the ore is fed from the hopper 25, onto the revolving hearth, and passes successively through the roasting and cooling portions 12-21 and 11-20. The fan 28 forces cold air through ore in the cooling chamber, and extracts heat from the cooling ore. This heated air is drawn by fan 31 from above the cooling ore, and delivered by pipes 33, 34 and 35 through the combustion chamber 36 and thence beneath the roasting portion of the hearth and upward through the layer of ore.

From the space above the roasting ore the gases are drawn into the condensing tower. The metallurgical features of the process are treated more fully on page 605. (1,075,011, Oct. 7, 1913.)

Vacuum Filters.

Continuous Vacuum Filter for Thickening Pulp.—Among the various devices tried at Anaconda for thickening slime pulp prior to concentration was the Garred filter, the invention of ULYSSES A. GARRED, of Anaconda, Mont. The filter may be briefly described as a "fixed" type of leaf filter, constantly submerged in the slime pulp, the filtering being accomplished by the aid of a vacuum, and the cake thus formed being discharged by a reverse pressure of water. The novel feature lies in the arrangement whereby the operation of a series of batteries of such filters is automatically controlled by valves which prescribe the periods of time during which filtering and discharging are continued. The operation is thus made continuous; the filter frame is not removed from the tank; a large volume of water is withdrawn, and the thickened slime discharged from the leaves settles to the bottom of the tank and is withdrawn through suitable openings. (1,072,111, Sept. 2, 1913).
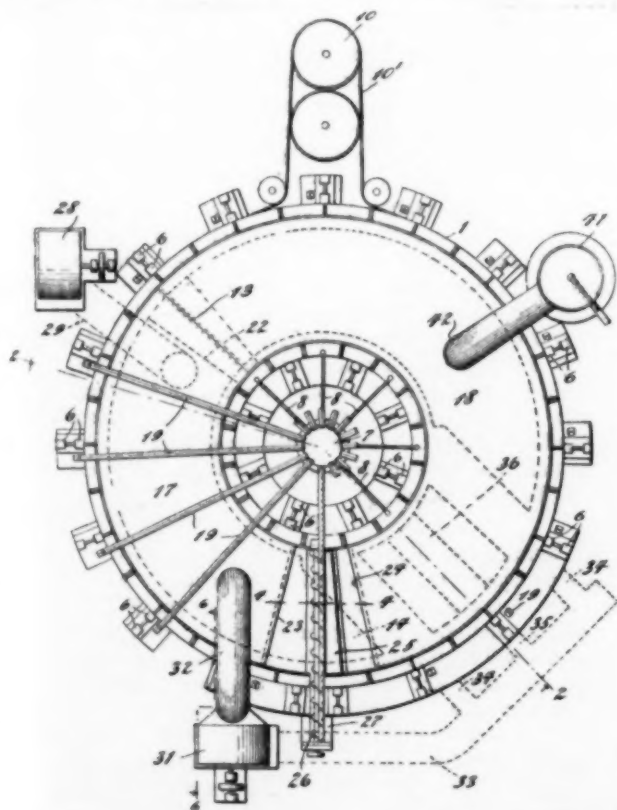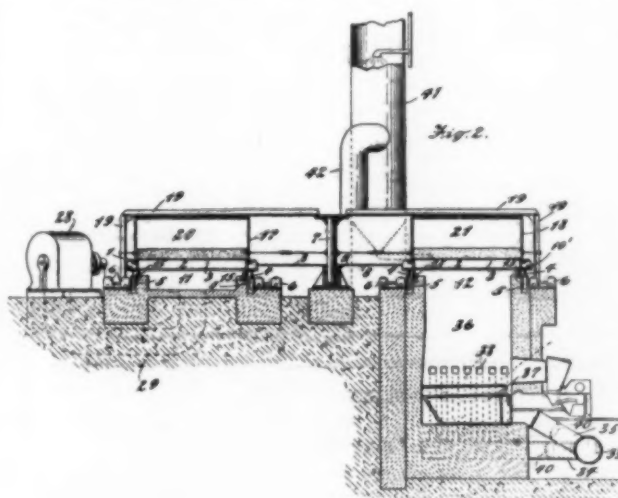

FIG. 9.—PLAN OF CHLORIDIZING ROASTING FURNACE

cooling and leaching. Features of the furnace are the means provided for conserving heat and for recovering the valuable constituents of the roaster gases.

Referring to Fig. 9, which is a plan of the furnace, and Fig. 10, which is a vertical section on the line 2-2 of Fig. 9, the numeral 1 indicates an annular deck with cast-iron frame 2, carrying a perforated grate 3. The deck and frame revolve, being driven by the rope 10' which encircles the deck and

Metallurgical Furnaces

Zinc Ore Roasting Furnace.—An improvement in mechanically rabbled roasting furnaces, particularly in the type in which sets of rabbles attached to an endless cable pass first through the furnace and then in the opposite direction outside the furnace, has been patented by Mr. Francis Curnow, of Pittsburg, Kans. Since it is not necessary to operate such furnaces continuously, an automatic mechanism is provided for stopping the rabbles, by means of a tripping device which is actuated by the rabble when it arrives at a predetermined point. An adjustable timing device is arranged to start the rabbles again after a predetermined interval of rest. (1,072,920, Sept. 9, 1913.)

An automatic charging device for roasting furnaces of the superimposed hearth type is shown in Fig. 11, being the patented invention of Ludwig Singer, of Bochum, Germany. In the crown 1 of the furnace 2 are arranged a number of
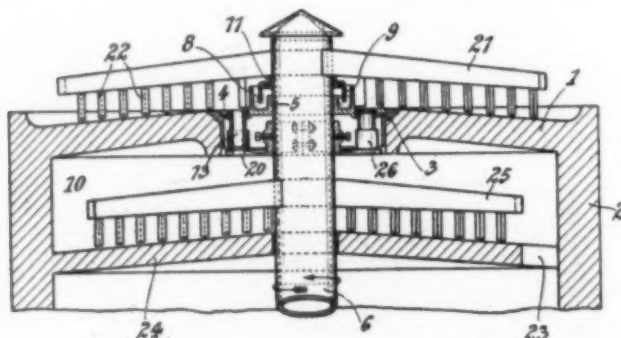

FIG. 11.—AUTOMATIC CHARGING DEVICE FOR ROASTING FURNACES

stationary, bottomless charging vessels 13 seated in a cover plate 4. These vessels are closed at their lower end by means of a false bottom secured to the central shaft and rotating therewith. The false bottom is provided with one or more openings 20 designed to register with the bottomless charging vessels during the revolution of the shaft. The volume of ore to be delivered to the furnace may be regulated by altering the
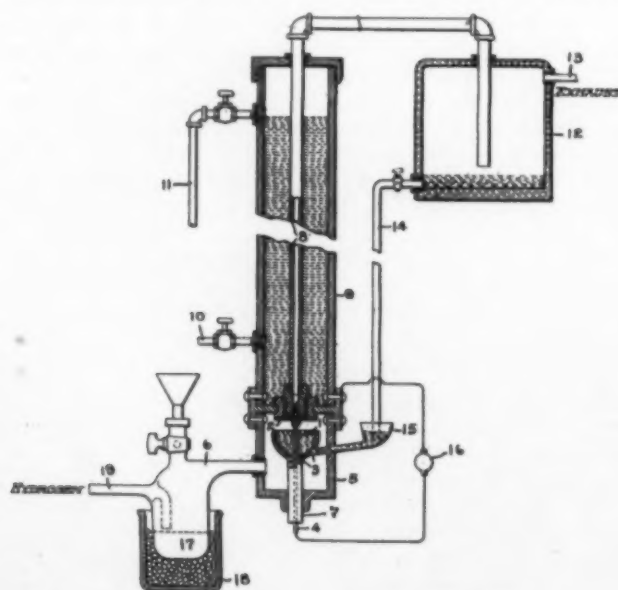

FIG. 12.—ELECTRIC ARC PROCESS FOR PRODUCTION OF BORON AND HYDROCHLORIC ACID

size of the charging vessels. In operation, the rake 21 delivers ore to the charging vessels which retain their charge until an opening in the false bottom allows the material to fall onto the upper hearth of the furnace. The arms of the rake 21 are related to the openings 20 in such a manner as to prevent the simultaneous filling and emptying of the charging vessels.

A sand seal formed by the annular walls 8 and 9 prevents the escape of heat and gas from the upper hearth of the furnace. (1,071,962, Sept. 2, 1913.)

Electric Arc Reactions

Boron and Hydrochloric Acid.—Joseph L. R. Hayden of Schenectady, N. Y., assigns to the General Electric Co. a process and apparatus for producing chemical reactions in an electric arc. Fig. 12 indicates how boric chlorid and hydrogen are caused to react in producing boron and hydrochloric acid. The arc is formed between a cathode of easily vaporizable material, such as mercury, zinc, cadinum or alloys, and an anode of perforated copper. The hydrogen for instance passes over the boric chloride (17) through the chamber 3, in which the arc is maintained, between mercury (1) and the copper (2). It carries enough of the liquid off for reaction. The products are cooled in the water-jacketed pipe (8). The excess of liquid returns through pipe (14) into the reaction chamber, the gas can be exhausted through pipe (13). The observations of the inventor indicate that the chemical activity is due, in part at least, to an electrical effect which is distinct from the purely thermal action of the arc. (1,072,945, Sept. 9, 1913.)

Acid-Proof Castings

Silicon Article.—Thomas B. Allen of Niagara Falls, N. Y., assigns to the Carborundum Company an interesting process of pouring articles of metallic silicon. The silicon and its alloys made in the electric furnace are said to contain silicon dioxide, nitrogen and oxygen, all in dissolved form. This fact has made castings of the metal very spongy and produced blow holes, and mechanically unsound castings. A large number of substances are able to combine with these impurities and produce stronger, denser and more perfect castings. Among the substances are the alkali and alkaline earth metals, magnesium, vanadium, titanium, aluminum, boron, etc. The inventor prefers metals like calcium, magnesium or vanadium which deoxidize and also remove nitrogen. Silicon is tapped from the electric furnace into a graphite crucible and held molten for one or two hours in a coke or oil furnace. To prevent losses, the surface is covered with a layer of coke. When the silicon is in a very fluid condition, from 0.5 to 3% of magnesium are added. When the magnesium produces no further reaction the silicon is poured, preferably from the bottom of the crucible. The mold is made of dry sand, and its surface coated with talc. The metal shows a marked absence of blow holes and flow marks, and consists of very fine crystals; the articles have considerable mechanical strength. The castings have high acid resisting properties, and are particularly useful as chemical ware. (1,073,560, Sept. 16, 1913.)

Alloys

An aluminium alloy capable of being rolled into thin sheets or otherwise manipulated as a malleable metal, is patented by William A. McAdams, of Bay Shore, N. Y. It contains aluminum, zinc and copper in such proportions that the aluminum will be substantially five times by weight the amount of zinc, and the zinc substantially five times by weight the amount of copper. The aluminum is first melted, and into this molten metal the copper is added in a cold state, preferably in the form of wire. This mixture is then cooled to a dull red, after which the zinc is added in the form of slabs, and the mixture stirred and cast. (1,072,017, Sept. 2, 1913.)

The Alaska Gold Mines company has 1200 acres of ground on which 50,000,000 tons of $1.50 ore have been developed. In the estimation of the company's engineers there is a total of 200,000,000 tons of such ore. The initial plant to be installed for the treatment of this ore will have a capacity of 6000 tons per day, and it is expected that a net profit of 75 cents per ton will be made. The ore will be mined through two tunnels driven on the 1600 and 2300 levels. The latter will be the main outlet and will be 10,000 ft. long. Eight thousand horsepower will be developed in two hydroelectric plants.

Regulating the Temperature of Liquids

In many chemical and industrial plants it is important to maintain water or any other liquid in a tank, boiler, etc., at a certain predetermined temperature. This is generally done by supplying through a valve, more or less steam (or hot water) to the tank or heating coil.

The problem of automatic temperature control is then simply to regulate the valve automatically in such a way that it admits just the right amount of steam which is required to maintain the temperature in the tank at the fixed value.

This problem is solved by the Sarco water temperature regulator in the following simple way:

As shown in Fig. 1, there are three principal parts: First, A, the thermostatic element which is inserted in the boiler or tank and which is thereby affected by the temperature of the liquid in the tank. The effect produced by any temperature variation in the thermostatic element A is transmitted from it
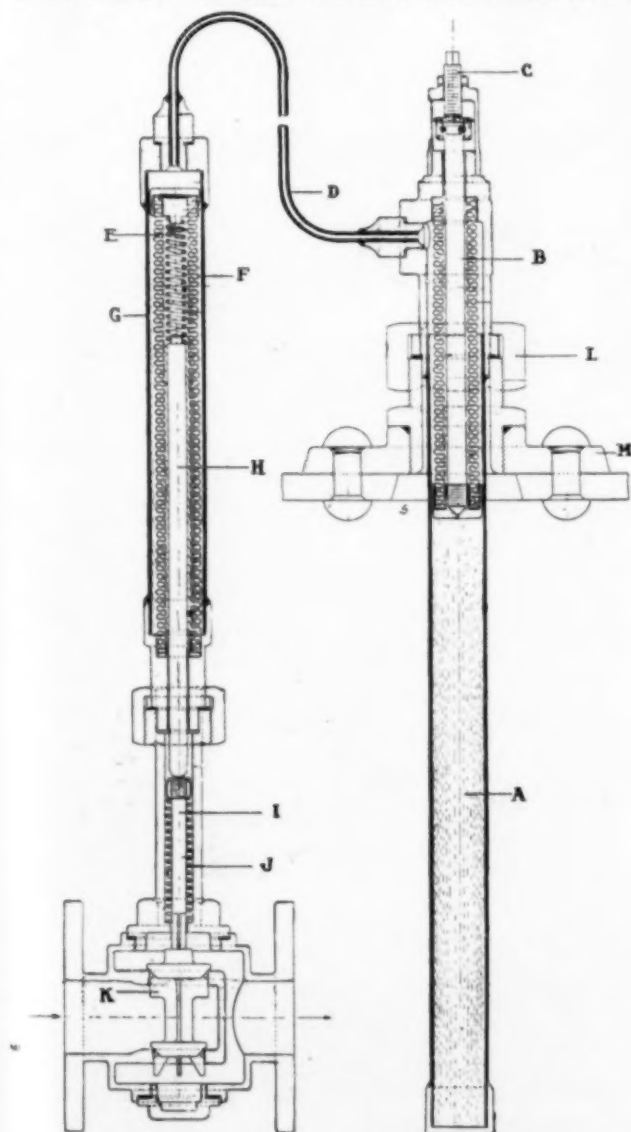

FIG. 1.—DIAGRAM OF WATER-TEMPERATURE REGULATOR

to the second principal part G, the controller element, and this acts directly on the third principal part, the valve, K, which controls the admission of steam to the tank and thereby controls the temperature in the tank. Let us now see how this transmission of effects is brought about.

The thermostatic element A is a tubular receptacle containing a heavy hydro-carbon oil into which is inserted at the top a piece of corrugated copper tubing B. This corrugated copper tubing is compressible and its length or the depth to which it

extends downwards into the tube A can be regulated by means of the screw head C.

From this thermostatic element A a piece of fine copper tubing D passes to the controller G which also contains a piece of corrugated copper tubing F. This corrugated copper tubing F is also capable of compression.

The thermostatic element A, the connecting tube D, and the controller G form one hermetically closed chamber.

If now the temperature in the tank should rise, the temperature of A also rises, and the oil in A expands. The pressure exerted is transmitted from A through D to the controller G (all three forming together one chamber) and the corrugated compressible copper tube F in G is compressed. This forces out the piston I and tends to close the valve K. The spiral springs E and J operating in the opposite direction tend to keep the valve open.

Hence, as a result of an increase of temperature in the tank, the valve K will close partly until a new state of equilibrium is reached, so as to admit less steam to the tank and keep the temperature in the tank at the predetermined value.

Of course, should the temperature in the tank tend to fall, the regulator acts in the reverse manner, opening the valve K further, etc.

FIG. 2—EXTERIOR VIEW OF WATER-TEMPERATURE RECORDER

The regulator is capable of quite delicate adjustment by means of the screw C, which permits to expand or contract the compressible corrugated copper tube B and thereby decrease or increase the space in which the oil is confined.

An exterior view of the whole regulator is shown in Fig. 2.

Some of the chief advantages claimed for the Sarco water temperature regulator are the compactness and simplicity of its design, the fact that it is wholly self-contained and requires no exterior operating means such as compressed air and the avoidance of rubber or leather diaphragms or of metal diaphragms. It is built by the Sarco Engineering Company, 116 Broad Street, New York City.

The Acimet Valve

The economical importance and absolute necessity of sulphuric acid and other corrosive liquids in many lines of manufacture, and the great annoyance and expense incurred in controlling and distributing these solutions by means of pipe lines, valves, etc., have given great importance to the problem of devising pipe and valves that would resist corrosion.

VALVE CONSTRUCTION

The solution of the pipe question was comparatively easy, as lead pipe was available for the purpose, and later lead-lined pipe entered this field, but the valve proposition was far more difficult to solve.

The approach to the solution was somewhat crude, as is often the case, but the ultimate result was most gratifying, producing as it did the Acimet valve, for which its makers claim not only high efficiency, but relative inexpensiveness.

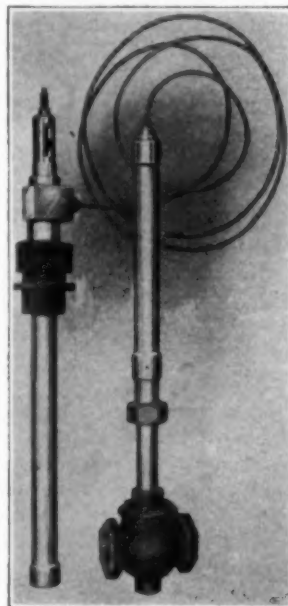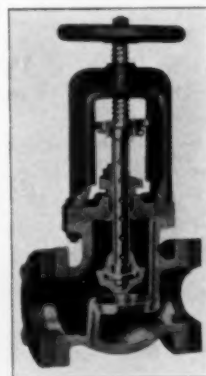Some of the very first Acimet valves made for experimental

purposes are still in service, having been used continuously for more than eight years, during which time they have required no repairs or attention except occasional packing.

When more recently the question of placing the Acimet valve on the market came up for consideration, it was realized that a symmetrical and harmonious design would be desirable. After much experimenting the formula for Acimet metal was developed and a mixture produced which has all the wearing qualities of sheet lead, and which can be cast and machined the same as brass or iron, and through an interesting method of reinforcing (as shown in the illustration), it is made stiff and rigid, so that no distortion of any kind takes place under any strain due to either pressure or piping.

The Acimet valve, the novel and original features of which are covered by letters patent, is made by the Cleveland Brass Mfg. Company (formerly the Cleveland Bronze & Brass Works), of Cleveland, Ohio.

Automatic Release Pen Lifter for Recording Instruments

The Industrial Instrument Company, of Foxboro, Mass., which manufactures an extensive line of recording instruments, has just perfected a new attachment for their recorders, for which patents are pending.

This attachment is called an automatic release pen lifter and is shown in the adjoining illustration. It can be attached to any Foxboro recorder. It is a very simple device consisting of a German silver strip mounted on a special holder, which is inserted under a screw head which holds the chart disc. A slight pressure on a small lever brings the strip up against the pen arm and lifts the pen from the chart. Friction holds it in the raised position, thus giving the operator free use of both hands for removing the used chart and supplying a new one. When the door is closed, the pen arm is automatically released
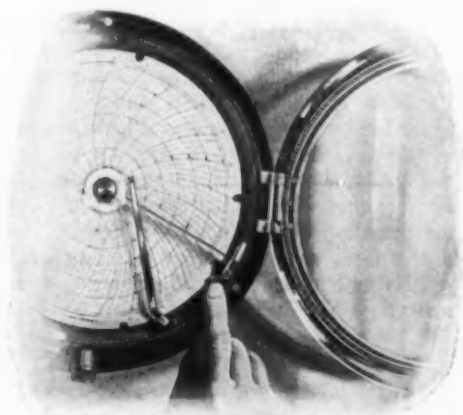
AUTOMATIC RELEASE PEN LIFTER

and the pen returns to its marking position on the chart. This automatic feature makes it impossible for the operator to forget and leave the instrument out of commission.

The device is very neat, and not only helps in the changing of charts but, what is more important, does away entirely with the necessity of handling the pen arm, with possibility of affecting the adjustment due to a slip or accidental strain. It also prevents accidents commonly resulting in spreading ink where it does not belong and is not desired.

Seamless Lap-Welded Steel Kettle

The adjoining illustration shows a large seamless lap-welded boiling kettle made by the American Welding Company, of Carbondale, Pa., for a prominent chemical company of this country. It is made of rolled steel plates bent into the desired shape and size. The inside diameter is 8 feet, the inside

depth 8 ft. 6 in., the width of the flange 4½ in. The shell consists of ¾-in. steel plate, the convex bottom is also ¾ in. thick. The capacity is 3000 gallons, the weight 9500 lb.

One of the great advantages of kettles made from rolled plate steel is that the construction is much lighter and stronger than that of kettles made from cast iron; as a result of the thinner walls the heat transmission is very much better. Further the plate-steel kettle can be thoroughly annealed so as to remove all inherent strains, while it is impossible to eliminate the strains in a cast-iron kettle.

The seams are heated by furnaces operated with water gas and are welded by either hammer impact or hydraulic power, forming a seamless weld about equivalent in strength and thickness to the plate itself, the surface of the weld being smooth on both sides. As the edges of the plates are lapped sufficiently to form a perfect weld no material other than
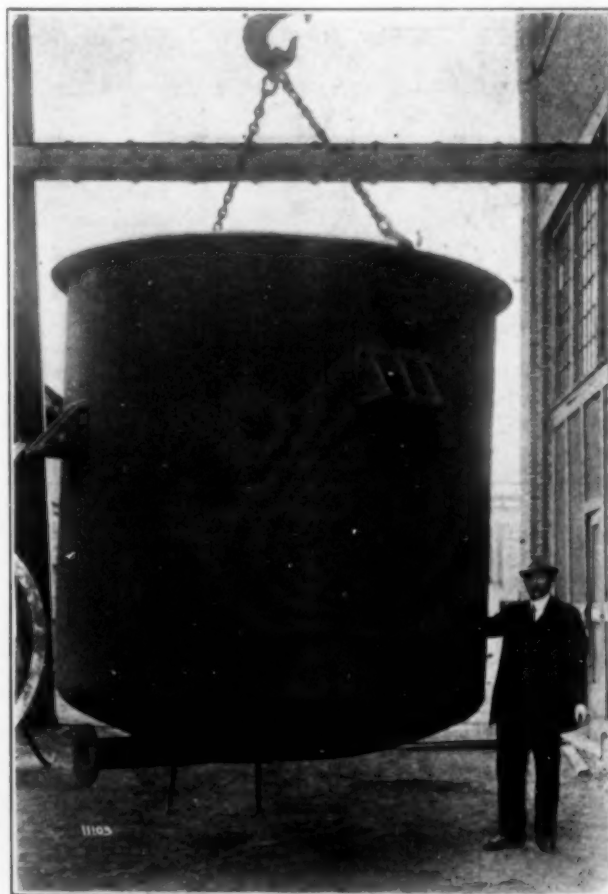
BOILING KETTLE

the edges of the plates is used in making the weld. Consequently a perfect lap-weld thus made is the same as the plate so that corrosion will not act upon the weld more rapidly than upon the body of the plate.

In the standard design of the American Welding Company the shell of the kettle at the top is flanged outward forming a right-angled flange. Supporting brackets of either cast iron, pressed or cast steel may be secured to the shell if preferred.

The kettle may be supported, however, by a specially designed ring base resting upon the furnace walls, the kettle being supported by its flange resting upon the ring. The advantage of such a method of support is obvious, as the shell of the kettle is kept intact and free from objectionable rivets. Replacements can be made at a minimum cost.

These kettles are made either plain or jacketed.

A metallographic study of the ores from the Silverton district, Colorado, is being made by Mr. B. F. Laney, under the joint direction of the Geological Survey and Bureau of Mines.

Multiple-Effect Water Stills

The multiple-effect water stills, built by the Pure Water Apparatus Company, Abbott Building, Philadelphia, Pa., are interesting in various ways.

First, an essential difference from the ordinary multiple-effect evaporator may be pointed out which is indicated by the fact that the Pure Water Apparatus Company builds multiple-effect stills with up to 20 effects.

The apparatus consists of a series of similar cells through which the heat units of the primary steam pass in succession, in each cell evaporating water to be purified and producing distilled water by the condensation of the steam which has brought this heat from the previous cell, thus producing at each exchange an additional quantity of distillate by the re-use of the original heat.

This process in itself is not new. The new feature is that while in the process just described a certain amount of the heat is lost by radiation from the outside of each cell, this loss of heat by radiation of each cell is automatically compensated by the addition of just the correct amount of steam to each cell in the Pure Water Apparatus Company's system.

Let us assume an eight-effect still with an initial steam pressure of forty pounds. This steam enters the first condenser and is condensed, and the water surrounding the condenser is evaporated and raised in temperature until a pressure of say twenty-five pounds is reached. But since we began with a pressure of forty pounds and want to use eight effects, we want to get at this point a pressure of thirty-five pounds. In order to get this additional pressure, steam is now let into the header from the main by a reinforcing valve (a patented feature which automatically maintains the desired pressure in each of the cells).

This process is repeated from cell to cell until the final cell is reached and the pressure and heat in the steam are fully utilized, the heat finally emerging as steam at atmospheric pressure from the last cell.

Each condenser is provided with a vent cock by means of which, together with other devices, the poisonous gases and air in this steam are separated from the steam and allowed to escape.

A coke compartment is provided to purify the steam and also to prevent entrained water being carried to the next condenser in the series. The distillate from all the cells passes through a heat exchange where it meets the cool incoming water to be used for supplying the various cells, and conserving the heat for further use in the stills.

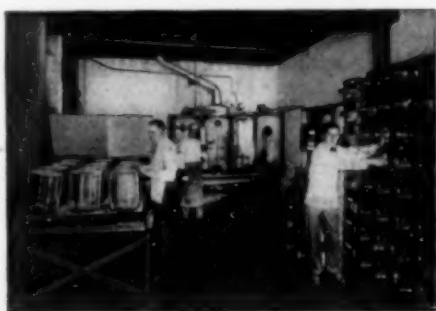From the heat exchange the accumulated distillate is passed

FIG. 1—STILL FOR SOLSCHEID WATER CO., KANSAS, MO.

through a charcoal cell which deodorizes the water, making it sweet and palatable.

After the distillate is finally collected and passed through the charcoal cell it is totally devoid of all deleterious and obnoxious gases. The high temperature at which the distillate is in contact with the steam in these stills makes it impossible to reabsorb these gases so that with this system aeration to destroy them is unnecessary. Aeration is a makeshift at best, the old theory being that contact with the atmosphere would remove these gases; as a matter of fact, contact with the sur-

rounding air simply changes their nature, but they still remain as impurities.

Still another important feature is the pretreatment apparatus or water softener which removes all scale forming ingredients from the incoming water before it enters the still. This pretreatment employs heat alone as the purifying agent and it is this system of softening water that assures continued economy under constant operation.

There are numbers of instances where these stills are operating after many years' service and no trouble has been en-
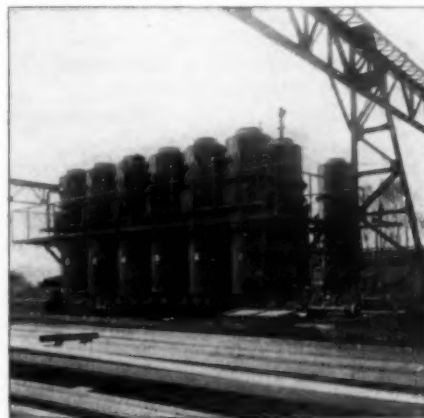

FIG. 2—INSTALLATION AT CURACOA, D. W. I.

countered due to scaling, using some of the worst alkali waters in the southwest.

This system has many other minor improvements which make for such economy of operation on a large scale that it is claimed to produce as many as fifty to eighty tons of chemically pure water per ton of coal—it being understood that the coal will evaporate in the boilers not less than eight pounds of water to one pound of coal.

Fig. 1 shows a small-size still which is at present in very successful operation for the Solscheid Water Co., Kansas, Mo. It is a 2500-gallon per 24-hour outfit of the two-effect type, giving about 1.7 lbs. of distillate per pound of live steam entering the initial cell.

Fig. 2 shows a large installation for the city of Curacoa, D. W. I., for their municipal water supply. It has a capacity 20,000 gallons per 24 hours, and is a 12-effect apparatus, producing more than 7 lbs. of distillate per pound of live steam entering the initial cell.

During a recent drought this machine not only supplied the needs of the city where it was installed, but was operated at 100 per cent. overload, supplying the additional drinking water for several nearby towns.

The Properties of Saturated and Superheated Ammonia Vapor

A very useful and interesting paper of 94 pages with the above title has been published as University of Illinois Bulletin, Vol X, No. 18 (University of Illinois, Engineering Experiment Station, Urbana, Ill.), the authors being Professor **G. A. Goodenough** and Mr. **Wm. Earl Mosher.**

The vapor of anhydrous ammonia first became of interest in the field of mechanical engineering with the advent of Carré's absorption and Linde's compression refrigerating machines. With the development and increased application of the refrigeration industry this vapor has become more important and an accurate knowledge of its properties is highly desirable.

The investigation of Professor Goodenough and Mr. Mosher was undertaken with the object of collecting and correlating the various scattered experimental data on the subject of the properties of ammonia and an attempt made to reconcile these data by means of well-known thermodynamic laws and prin-

ciples so that the results may be consistent with each other; and to express the various properties by means of formulas from which tables and charts in English units could be prepared for use in solving the many problems connected with refrigeration work.

The chief results of the investigation are given in form of four tables on twenty-seven pages.

Of the four tables given, the first and second are for the liquid and the saturated vapor of ammonia and give explicitly all of the properties that are ordinarily needed for use. Table 3 is primarily for superheated ammonia vapor, but includes the saturated vapor as the special case of zero superheat. Table 4 gives the thermal properties of liquid ammonia.

In tables 1 and 4 the argument is the temperature. In tables 2 and 3 the argument is the pressure.

Then follows a chapter on the Mollier diagram for ammonia.

In order to facilitate the solution of refrigeration problems, a heat content-entropy diagram was prepared which accompanies this bulletin. This diagram has two families of curves: (a) curves of constant pressure, and (b) curves of constant quality in the saturated region and constant temperature in the region of superheat. The ordinates are heat contents; the abscissas are entropies.

The tables given in the paper are based upon the most reliable experimental data available at the present time. In the final chapter this body of data is presented together with the derivation therefrom of the formulas from which the tables were calculated.

Anyone interested in refrigeration problems should acquaint himself with this excellent and useful work.

Personal

Mr. **Courtland F. Carrier, Jr.**, who has been chemical director of the Vulcan Detinning Co. for the past four years, has severed his connection with that company and removed to St. Louis, Mo., where he is taking up a general consulting chemical engineering practice with Mr. James C. Lawrence of Memphis, Tenn., under the name of Lawrence & Carrier, Inc.

The Dorr Cyanide Machinery Co. has opened a New York office at 50 Church Street, to take care of its expanding business in metallurgical work and industrial lines. The office will be in charge of Mr. **H. N. Spicer**, one of the company's engineers. **Mr. Dorr** also will spend a large part of his time in the East, devoting himself to the company's business and professional work.

Mr. **W. H. Gibb**, for five years Pittsburgh representative of the Brown Instrument Co., was made general manager of sales of the Stupakoff Laboratories of Pittsburgh, Pa.

Mr. **W. Gowland**, emeritus professor of metallurgy in the Royal School of Mines, London, will publish a treatise on the metallurgy of the non-ferrous metals.

Mr. **Simon Guggenheim** has been elected chairman of the boards of the several Guggenheim corporations, American Smelting & Refining Company, American Smelters Securities Company, and Guggenheim Exploration Company.

Mr. **Franklin Guiterman** has returned to New York from one of his periodical visits to the Colorado offices of the American Smelting & Refining Company.

Messrs. **Charles Hayden, D. C. Jackling** and **C. M. Mac-Neil** have completed a tour of the western zinc and copper properties under their control, and have gone to Alaska to inspect their gold mining interests.

Mr. **Julius Marcus**, until recently chemist with the Ray Consolidated Copper Company, Arizona, has accepted a position with the Braden company in Chile.

Mr. **Seabury C. Mastick** announces that he has admitted Mr. **Henry J. Lucke** into partnership under the firm name of Mastick & Lucke, attorneys and counselors at law, 2 Rector street, New York City. Mr. Lucke is a graduate of Johns Hopkins University, was for two years an instructor of chemistry, physics, and mathematics at Lafayette College and for seven years and a half was an assistant examiner in the U. S. Patent Office, serving in the division of electrochemistry and metallurgy and electricity, and for the past five years was practising law in New York City.

Mr. **J. B. Shatzer**, Pittsburgh representative of the Schutte & Koerting Co., will give a "Safety First" lecture on automatic engine stops and triple service valves before the National Association of Stationary Engineers in Pittsburgh on November 17.

Mr. **F. W. Skirrow**, chemical engineer, has accepted a position on the teaching staff of the University of Colorado, at Boulder, and will give lectures in industrial chemistry, at the same time remaining open to engagement in a consulting capacity.

Mr. **E. J. Wagor** has been superintendent of the melting and refining departments of the United States mint at San Francisco.

Mr. **F. L. Zimmerman** has been appointed Eastern representative of the Hoskins Manufacturing Company, of Detroit, makers of electric furnaces, pyrometers and heating appliances, to succeed Mr. E. L. Smalley. His headquarters are at 30 Church Street, New York City.

Notes

The Colorado Chapter of the A. I. M. E. has been organized with the following officers: Wm. J. Cox, chairman; C. J. Moore, vice-chairman; C. L. Colburn, secretary-treasurer; T. B. Stearns and Richard A. Parker, members of the executive committee with the officers. The chapter has jurisdiction in the state of Colorado.

The **Abbe Engineering Company**, of 220 Broadway, New York, announces that they have purchased the Sellman Mill Company and the pulverizing and grinding machinery business of G. M. Ball & Son, together with all the patents, drawings, patterns, good will, etc., of the foregoing concerns so that they are in a position to supply new mills, also repairs and supplies for the machines bought of these concerns. Mr. Henry Sellman, who has been building pebble mills and installing complete grinding plants for the past thirty-four years, is now with the Abbe Engineering Company in their engineering department. The Abbe Engineering Company state that they now control over thirty patents on various kinds of pulverizing and grinding machines.

High-Voltage Testing Transformers and Complete Testing sets is the title of Bulletin 570 of the American Transformer Company, of Newark, N. J. Two standard equipments are described, one for 50,000 and the other for 5,000 volts.

Electroplating with Trisalyt, the useful little pamphlet of the Roessler & Hasslacher Chemical Company, 100 William St., New York City, on the use of trisalyt (a metallic triple salt for electroplating copper, brass, bronze, zinc, gold and silver) has now appeared in the fourth edition. An interesting new edition is a formula for salt water gilding

Irrigation is the title of a very neat and beautifully illustrated pamphlet of the Henry R. Worthington Hydraulic Works, 115 Broadway, New York City, on the conservation and distribution of water for irrigation, with many technical details of pumping machinery and tables of useful information on irrigation work.

The Log-Book of the Tower Plant is the title of an illustrated circular of the Yarnall-Waring Co., Chestnut Hill, Philadeiphia, Pa., on the construction and uses of the Lea V-notch recording liquid meter. This liquid flow meter was described in our October issue, 1911, (Vol. IX. pp. 557), and also was the subject of an elaborate paper by Mr. D. Robert Yarnall before the annual meeting 1912 of the American Society of Mechanical Engineers. This paper has also been reprinted by the Yarnall-Waring Co. in pamphlet form.

Interesting Photographs from the Field is the title of a little and very neat booklet published by the Hardinge Conical

Mill Company, 50 Church Street, New York City, showing rather interesting photographs of some large mill operations in this country, as well as some typical Hardinge mill installations.

Pure Iron versus Copper-Bearing Steel is the title of Bulletin 5 of the Institute of Industrial Research, of Washington, D. C. The sub-title of this pamphlet of 47 pages describes it as "a brief for the plaintiff with historical data bearing upon the development of rust-resisting metals in the United States." The author is Dr. Allerton S. Cushman. In conclusion "the writer can only express the hope that those engineers and others who are accustomed to purchase material under carefully drawn specifications will not be influenced by a movement which proposes to overcome the bad effects produced by the usual impurities in steel by the simple expedient of adding another one (copper). The modern tendency throughout the whole great field of industrial development is towards a higher purity of product. The development of a pure iron as a commercial possibility is in line with this general progressive movement. It would be regrettable if this evolution in the iron industry should be retarded or halted by this retrogresssive propaganda in favor of a special type of extra impure steel. It should always be remembered that the best is rarely the cheapest or the easiest to produce in any line of industry."

Tungsten Ore in Burma.—According to a consular report, wolframite has been discovered in the Tavoy and Mergui districts and a large number of concessions are being worked. The greater part of the output comes from float deposits and the ore is concentrated by the natives with pan, sluice-box and rocker. The average concentrates contain about 65 — — WO_3. The cost of recovery and transportation to England is about $315 per ton; but with ore selling at $7 to $8 per unit a good profit remains.

Digest of Electrochemical U. S. Patents
PRIOR TO 1903.
Arranged according to subject-matter and in chronological order.
Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.
REFINING METALS (*Continued*).

533,596, dated Feb. 5, 1895, Henry A. House, of Bridgeport, Conn., assignor of one-half to Robert Rintoul Symon, of London, England.

Relates to apparatus for refining metals, particularly silver, by electrolysis. In a suitable tank or vat is a horizontal shaft, with means for rotating the same, and on said shaft I mount one or more cathodes and one or more anodes of the impure metal to be refined. The cathodes upon which the metal is deposited are in the form of segments of a disk carried by an insulating support and adapted to be alternately connected with the circuit while in the solution and cut out of circuit during that part of their movement when they are out of solution. The anodes of impure metal are also carried by suitable supports, and may be cast in the form of annular disks or in segments that are secured to such support and similarly arranged to be brought into and cut out of the circuit. Under each rotating electrode is a removable canvas bag to catch the impurities or particles of metal that fall from the electrodes, and under all the electrodes and bags a still larger removable bag. Above the level of the solution are brushes that sweep over the surface of the anodes for removing bubbles of gas and impurities that collect thereon; and scrapers that bear on and remove from the cathodes the film of deposited metal and cause it to drop into a suitable trough. When the electrodes are rotated, current passes from each anode segment through the solution to the opposite cathode segment, the electrode segments out of the solution being cut out of circuit. By the use of a proper solution and current density, the silver is deposited on the cathode segments in a loose, spongy state from which it may be scraped by scrapers into the troughs or bags beneath.

545,328, Aug. 27, 1895, William H. Wiggin, of Worcester, Mass.

Relates to a process and apparatus for refining metals, etc., by electrolysis. The apparatus consists of a series of tanks having guides attached to the inner sides for holding electrodes in a vertical position. Above the tanks is a shaft on which are a plurality of cams, and levers pivoted on supports and their free ends resting on the cams. At an intermediate point, the levers support the electrodes in the tanks. The rotation of the cams oscillates the levers, which in turn impart a sudden shaking movement to the electrodes, removing any accumulated gas bubbles or impurities adhering thereto. The impure metal plates are electrolyzed as secondary electrodes, the electrolyte maintained in circulation by feeding it in at one end and withdrawing it at the other end. The patent contains a reference to patent 467,484.

546,364, Sept. 17, 1895, Donato Tommasi, of Paris, France.

Relates to the refining of metals by electrolysis. The apparatus consists of stationary anodes of the metal to be refined and a rotary cathode, the latter consists of a radial frame mounted upon a shaft, and adapted to receive sectors of conducting material, such as metal, or an agglomerate of carbon and copper oxide, the latter being reduced by the hydrogen, thereby reducing polarization. The rotating cathode sectors are so connected electrically that only the submerged parts are connected, the exposed parts absorbing oxygen from the air and in turn serving to reduce polarization. Scrapers remove the deposited metal as the cathode leaves the solution; the mechanical rubbing also reducing polarization. When metals are to be plated from solutions, anodes consisting of spongy or reduced metal, such as copper, lead, etc., whose oxide is insoluble in the electrolyte, are used; these take up the oxygen, and are later electrolytically reduced in a separate cell. The apparatus and process may be used for refining and obtaining copper, lead, zinc, nickel, silver, tin, argentiferous slags, matte, speiss, ores, etc., also obtaining the silver from Pattinsonized lead or skimmings, etc., appropriate electrolytes being used.

566,673, Aug. 25, 1896, Charles W. Fielding, of London, England, and Louis B. Walker, of Elizabeth, N. J.

Relates to electrolytic refining of metals, using secondary electrodes; the anodes to be either of cast or rolled metal; and attached cathodes of metal or material either similar or dissimilar to the metal in the anode, but preferably made of a paste spread over one side of the anode and allowed to harden before use. The several compound plates are separated by spherical insulators suspended on a cord or other carrier. The spheres touch in points only, and therefore permit the consumption of the entire anode.

569,722, Oct. 20, 1896, John T. Morrow, of Great Falls, Mont.

Relates to the refining of metals and is for a cage or receptacle for containing the ends and scraps of anodes. The cage may be made of metal less electropositive than the scrap copper in the electrolyte, in which case only the scrap copper will be anodically dissolved; or of non-conducting material and make contact with the scrap copper through a copper shoe resting upon the scrap which is replenished as fast as it dissolves.

570,133, Oct. 27, 1896, William DeCourcy May, of Niagara Falls, N. Y.

Relates to refining metals, and consists of a series of similarly shaped vertically nested pans, which may be made of the metal to be deposited, or of non-conducting material. Electrolyte is supplied to the top pan, and overflows to the one below at one side; from this pan it overflows to the next lower one from the opposite side, thereby circulating the electrolyte in each pan. From the bottom pan it overflows into a receptacle in which it may be purified before re-use. The anode consists of metallic shot or other fragments, which is placed within each pan, the cathode being the underneath submerged side of the pan above, the electrolyte in each pan rising above the level of the underside of the upper pan. When of non-conducting material, a conducting coating is applied as cathode, and suit-

able connection made from the coating to the copper shot within.

578,953, March 16, 1897, Frederic A. Thum, of Newark, N. J.

Relates to an apparatus to be used in refining metals, which consists of a long oblong tank, which may also be annular, in which is placed the electrolyte and the cathodes. Suspended within the tank are smaller cells or carriages, supported by wheels running on a track without, and upon which the cell may reciprocate. The cell has a perforated bottom covered by a filter cloth, on which is placed the metal to be refined, either in a fragmentary condition, or otherwise. Anodes made of metal to be refined rest upon the fragments and make contact through a flexible wire and roller to a rail conductor. The cathode may be a plate in the bottom of the outer tank, or may consist of a number of removable pans in which the deposit is made. The reciprocation of the cell stirs the liquid and removes bubbles, etc. Anode slimes are retained on the filter cloth.

588,035, Aug. 10, 1897, William Thum, of Newark, N. J.

Relates to apparatus used in the refining of metals, which consists of a tank having a slanting bottom, with a trough at the lower end of the bottom. The cathode rests on the slanting bottom and projects into the trough. Anode cells similarly shaped, and lined with filter cloth, are slidably mounted in the tank, and have a perforated slanting bottom parallel to that of the tank. The metal to be refined is placed, in a fragmentary state, in the anode cell, contact being made through a removable casting of the metal placed thereupon. Within the trough at the bottom of the tank is placed a removable receptacle of porcelain, etc., into which the deposited metal is pushed periodically. A similar trough and receptacle are in the anode cell, to collect the slimes. The liquid is suitably circulated by an injector, or by compressed air.

588,524, Aug. 17, 1897, Edward Balbach, Jr., of Newark, N. J.

Relates to apparatus for refining silver and other metals, which consists of a tank of earthenware, etc., having a bottom partly flat and the remainder inclined, the entire bottom preferably covered with carbon plates or other conductor. Within this tank are removable skeleton frames which have grated bottoms; the frames contain removable anode compartments having filter-cloth bottoms. Upon the filter cloths are placed the bars of metal to be refined, to which contact is made by the removable castings of the metal electrically connected to the positive pole. The deposited metal collects as crystals, etc., and is periodically removed by a scraper. The anode slimes remain upon the filter cloth.

Book Reviews

Metallurgy. By **Cecil H. Desch.** Second edition; small octavo (18 x 11.5 cm.); 411 pages, 14 plates, 108 diagrams. Price $3.00 net. New York and London: Longmans, Green & Co.

For this new edition additions have been made to bring the work up to date, while the chapters on the physical properties of alloys and on the metallography of iron and steel have been practically rewritten. The method of handling the subject matter and the author's style are considerably better than in the first edition (which itself, however, was well done), so that this new edition may be unreservedly recommended as a clear, systematic and skilful presentation of the subject.

* * *

Liquid Steel: Its Manufacture and Cost. By **David Carnegie,** assisted by S. C. Gladwyn. Octavo (14 x 23½ cm.), 520 pages, 10 plates and 252 illustrations. Price 25 shillings; in New York $7.50. London and New York, Longmans, Green and Co.

The author was formerly a Sheffield steel maker, and is now steel works consultant and engineer; his assistant is a consulting engineer. Their chief aim is to compare systematically the costs of all the steel-making processes, giving details of composition and cost of raw materials, construction and arrangement and cost of furnaces and plant, and tabulation of labor costs and cost of living in different countries.

The work, however, contains more than this; it gives incidentally a larger amount of information about the processes themselves, and the principles upon which they are based and worked, given in a clear and succinct manner.

The antiquated £. s. d. make the reading and comparison of costs very unsatisfactory to anyone but a Britisher; but we feel thankful for cwts. and quarters having been replaced by tons and pounds. The illustrations, plates, paper, type and binding are all satisfactory. The book will prove valuable to a large circle of technologists.

The following figures and conclusions from the work may interest others than mere technologists: They give in relative figures the wages received for the same kind of labor, the expense for the same kind of living, and the relative state of "affluence" of the workingman, in the countries named, taking England in each case as the standard:

	Germany	England	America
Wages received	75	100	200
Cost of living	120	100	150
"Coefficient of comfort"	62.5	100	133

In brief, the German workman is on an average 37½ per cent. worse off and the American 33 per cent. better off than the English; or the American may be said to be 113 per cent. better off than the German. These figures are strictly true only of the iron and steel industry, but they agree fairly well with the reviewer's observations and conclusions in other industries; they therefore approximate to being true in general.

* * *

A New Era in Chemistry. Some of the most important developments in general chemistry during the last quarter of a century. By **Harry C. Jones.** 326 pages. Price $2.00 net. New York: D. Van Nostrand Company.

"Although the development of chemistry has taken place more or less by leaps and bounds, it is difficult to fix an exact date as the beginning of the 'New Era.' The year 1887 marks the appearance of the first volume of the *Zeitschrift für Physikalische Chemie,* and in this volume the epoch-making papers by Van't Hoff, on the Relations between Solutions and Gases, and of Arrhenius on the Theory of Electrolytic Dissociation appeared. This date, 1887, is, therefore, taken as the beginning of the New Era, which is, then, a quarter of a century old.

"It is, however, clearly recognized that there is a difference between the chemistry of twenty-five years ago and that of to-day. That this is really a difference in kind is not always clearly understood, either by those who have watched the development during that period or by those who have not studied chemistry long enough to have the necessary perspective.

"It has seemed desirable to point out as clearly as possible in what this difference consists; how these new developments were brought about and by whom. This is the object of this little work."

There are twelve chapters dealing with the conditions of chemistry in 1887; development of the law of mass action; the energy changes that take place in chemical reactions; Van't Hoff, Le Bel and Guye and the origin of stereochemistry; the phase rule of Willard Gibbs; chemical dynamics of Van't Hoff and chemical and chemical equilibrium of LeChatelier; the rôle of osmotic pressure in the analogy between solutions and gases; Arrhenius and the theory of electrolytic dissociation; the salvate theory of solution and the importance of solutions for science in general; the work of Wilhelm Ostwald in inaugurating the new era in chemistry; investigations by the students and coworkers of Wilhelm Ostwald; the electron and radiochemistry.

This book is testimony of a sympathetic nature and its charm rests to a large extent in the author's personal reminiscences of Van't Hoff, Arrhenius and Ostwald. The title of the book is undoubtedly too broad for its contents, but those phases of the new era of chemistry which are connected with these three men are covered with genuine enthusiasm.